Issued May 29, 1909.

U. S. DEPARTMENT OF AGRICULTURE

BIOLOGICAL SURVEY—BULLETIN No. 33

C. HART MERRIAM, *Chief*

THE BROWN RAT IN THE UNITED STATES

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DAVID E. LANTZ

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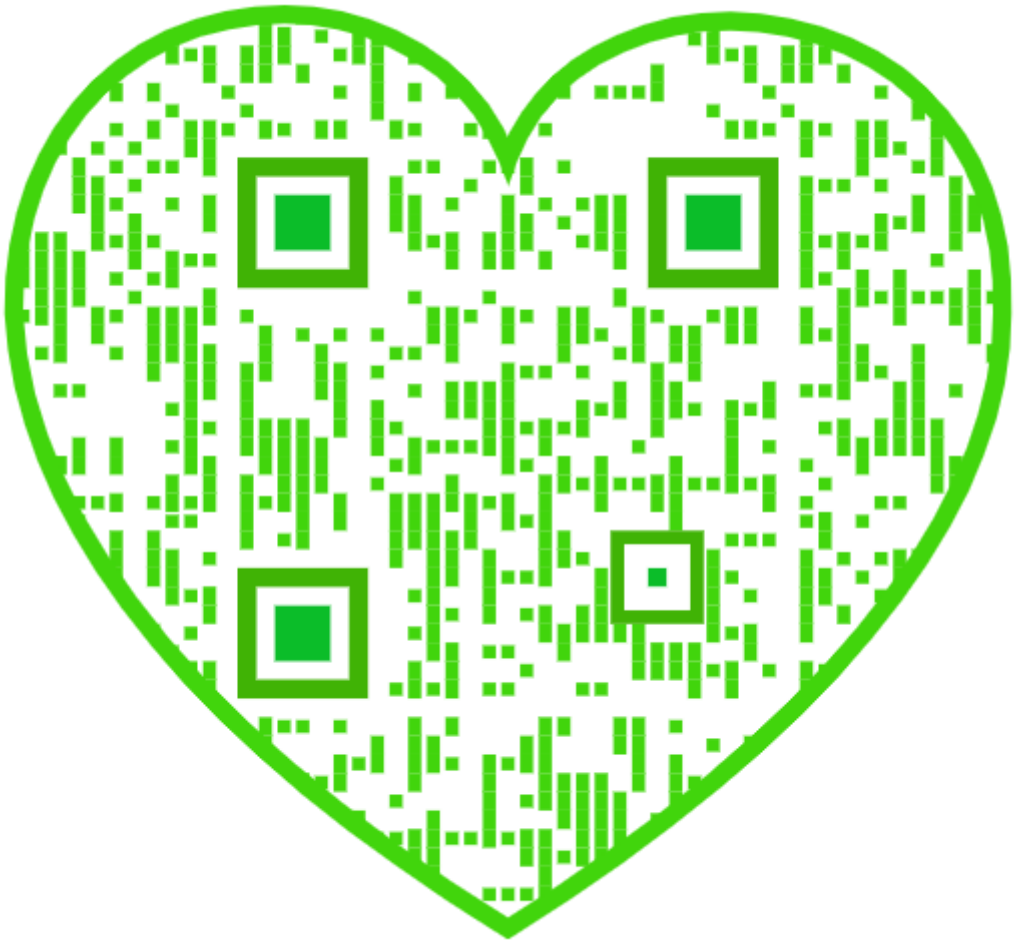

FIG. 1.—BROWN RAT.

FIG. 2.—BLACK RAT.

[From skins. One-third natural size.]

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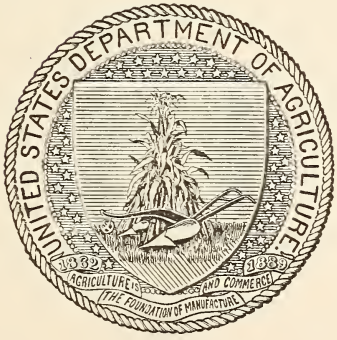

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LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Biological Survey,
Washington, D. C., January 28, 1909.

Sir: I have the honor to transmit herewith a report on the Brown Rat in the United States, by Prof. David E. Lantz, and to recommend its publication as Bulletin No. 33 of the Biological Survey.

The rat is believed to be the worst mammalian pest known to man. Not only does it damage property to the extent of many millions of dollars annually, but to this pecuniary loss must be added the still greater harm it inflicts by the dissemination of the dreaded plague and other diseases. Boards of health of many maritime cities in this and other countries are now engaged in an active campaign against rats, but thus far without very gratifying success. In Japan, where the Government is awake to the seriousness of existing conditions, the number of rats destroyed annually, according to Professor Kitasato, varies "from several hundred thousand to a million. Nevertheless at the present day no appreciable diminution in the number of rodents can be noticed. Reproduction keeps pace with destruction, so that we are at a loss to know how to proceed." In order to secure effective cooperation it is important to impress on the public the need of concerted and sustained effort, and particularly the necessity of depriving these noxious animals of the lavish supply of food and shelter now unwittingly furnished them. In this connection it is believed that the present bulletin will prove helpful.

Respectfully,

C. Hart Merriam,
Chief Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

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THE BROWN RAT IN THE UNITED STATES.

INTRODUCTION.

The rat is the worst mammalian pest known to man. Its depredations throughout the world result in losses amounting to hundreds of millions of dollars annually. But these losses, great as they are, are of less importance than the fact that rats carry from house to house and from seaport to seaport the germs of the dreaded plague.

Once occupying only a comparatively small part of the Old World, through the spread of commerce the brown rat has been furnished free transportation to the uttermost parts of the earth, while its fecundity, cunning, and adaptability to almost every kind of environment have enabled it to flourish and multiply wherever it has secured a foothold.

Man s antipathy to the rat is not new. For centuries the animal has been banned, and human ingenuity has been taxed to the utmost to suppress it. Innumerable devices in the way of traps, poisons, gases, and, more recently, cultures supposed to spread fatal diseases have been resorted to. Nevertheless, the pest continues to prosper, and its numbers and destructiveness keep pace with the advance of civilization. Everywhere the history of the contest is the same. Though thousands are killed, the relief is only temporary, and other thousands soon replace the slain. Therefore, if conducted along the old lines, the war promises to be never-ending.

The futility of past efforts and the lack of permanent results indicate that the real cure for the rat evil in cities, especially seaports, lies in preventive rather than curative methods. The extraordinary success that has attended the rat's struggle for existence is to be explained largely by the abundance of food and shelter furnished by man. Preventive measures should be directed to withholding these advantages. The curtailing of food is less important in its effect on the present rat population than in its certain result in lessening reproduction. Abundance of food means many young in a litter and many litters in a year; a restricted supply means fewer young and fewer litters. The most important steps, therefore, toward the suppression of the rat are:

(1) *The enactment and strict enforcement of municipal ordinances providing for the disposal of garbage and the protection of food supplies.*—Every effort should be made to instruct the public as to the necessity

for care in the disposition of refuse and the protection of food materials. Tightly closed garbage cans frequently emptied will go far toward limiting the food available for rats. Grain bins in private and public stables, now affording food and harborage for thousands of rats, and public markets and feed, provision, and grocery stores, notoriously lacking in protection against rats, should have their contents safeguarded from these animals.

(2) *The rat-proof construction of dwellings and public buildings.*— The advantages of cement in the cellars and foundations of public and private buildings are now so well understood that the rat-proofing of buildings by cement construction and other necessary measures should be no longer left to individual inclination and judgment, but should be incorporated in building regulations, and these strictly enforced. The additional expense, compared with the advantages, is trivial.

The above measures are of first importance, but they will not entirely solve the problem of rat repression. The destruction of rats, wherever they are numerous, is very important and at times absolutely necessary in the interests of public health. Hence in the following pages are given the best methods known for destroying rats, many of which have been developed by experiments and practical trials. Such methods, however, are fallible and at best inferior to preventive measures. The cutting off of the chief sources of food supply will limit the increase of the pests to a minimum, while the general construction of rat-proof buildings will deprive them of shelter and breeding places. The two measures will thus strike at the very root of the evil, and if supplemented when necessary by a vigorous campaign of destruction will prove vastly more effective, much less expensive, and productive of far more enduring results than any measures hitherto attempted.

DESTRUCTIVENESS OF THE BROWN RAT.

At the head of the rat family for destructiveness stands the brown rat (*Mus norvegicus*), called also gray rat, house rat, barn rat, wharf rat, and Norway rat. (Pl. I, fig. 1.) Like all members of the genus *Mus* found in America, the animal is not a native, but is an immigrant from the Old World. In spite of constant warfare waged against it, the brown rat has steadily increased in numbers, and has spread to almost all parts of the country reached by railways or by steamship lines. Accidentally brought to our shores after the middle of the eighteenth century, in most places it has driven out or exterminated its less robust relative, the black rat. The dominance of the brown rat is probably due to its superior strength and ferocity, its greater fecundity, its peculiar adaptability to various environments, and its more pronounced burrowing habit.

The present bulletin is intended to acquaint the public with the habits of the brown rat,[a] the nature and extent of the losses inflicted by it, and the best available methods of fighting it. It is believed that such knowledge will result in more persistent attempts, through cooperation and individual effort, to exterminate the pest, or at least permanently to reduce its numbers.

DISTRIBUTION OF THE GENUS MUS IN AMERICA.

True rats and mice belong to the Old World genus *Mus*, of which nearly 300 species have been described. Of these about seven-eighths are properly to be classed as rats and the remaining one-eighth as mice. Among all the species of *Mus* four have developed the ability to adapt themselves to such a variety of conditions as to climate and food that, carried on ships, they have established themselves in many parts of the world. These four are the only species of *Mus* that have become acclimatized in America.

The common house mouse (*Mus musculus*) found its way to America soon after the first settlement by Europeans. It is now distributed in all settled parts of North and South America, but in the extreme north it does not always survive the winters, and is therefore scarce.

The black rat (*Mus rattus*) (Pl. I, fig. 2) was carried to South and Middle America about three and a half centuries ago. The time of its arrival in the English colonies of North America is uncertain, but it was well established in the settled portions by the beginning of the eighteenth century. After the arrival of the brown rat, it began to decrease in numbers and gradually to disappear until it has become rare in most parts of the United States and Canada. It is now found in scattered colonies mostly east of the Mississippi Valley and on certain islands along the coast on both sides of the continent. It is occasionally observed in most of our seaports. The Biological Survey has specimens from Massachusetts, New Hampshire, Georgia, Florida, Alabama, California, and Washington, as well as from Mexico, Honduras, Nicaragua, and Hawaii. Also there are authentic records of its recent occurrence in Newfoundland, Quebec, Nova Scotia, New York, North Carolina, Tennessee, West Virginia, and Mississippi. In parts of South and Middle America the black rat has been more persistent and is still abundant.

The roof, or Alexandrian, rat (*Mus alexandrinus*) is similar to the black rat in form and habits, though not in color. Little is known

[a] While this paper deals primarily with the brown rat, some of the illustrative facts quoted throughout the following pages refer to the black rat (*Mus rattus*) and to the roof rat (*Mus alexandrinus*). The habits of the three species differ so little that the methods given for combating them apply to all. In some of the discussions of losses caused by rats it has not been practicable to exclude those due to the common house mouse (*Mus musculus*).

of its history, but it is supposed to be a native of Egypt, where it is still abundant. It is almost as remarkable as the brown rat for its wandering propensities, and it is probably quite as common on sea-going ships. It has established itself in seaports in many parts of the world, mainly in warm climates, and is common near the coast in southern parts of the United States. The Biological Survey has specimens from North Carolina, Georgia, Florida, Alabama, Mississippi, Texas, Arizona, and California. In the last-named State it is abundant in the Sacramento Valley. The species is known from Lake Drummond, Va., and from Cuba, the Bermudas, Trinidad, San Domingo, Costa Rica, Nicaragua, Mexico, and Hawaii. It occurs also in many parts of South America, where it is often the dominant species.

In most parts of the United States the rat common about houses and barns is the brown rat. It is larger and more robust than either the black rat or the roof rat, and differs from them considerably in habits. Unlike them, it almost always burrows in the ground under buildings and in loose soil along hedges and river banks. This habit affords better protection from enemies and, combined with the animal's greater ferocity, has enabled it to supplant the other species in temperate latitudes; but in the warmer parts of America it has not always been able to do this, and the roof rat appears to be most numerous in many localities.[a] The house mouse escapes the brown rat by taking refuge in crevices and other retreats too small for its foe to enter.

The brown rat inhabits most of the thickly populated parts of America. North of Panama it occurs from the Isthmus to the Yukon Valley and to Greenland, except on the interior table-lands and perhaps in a few sections of the South. Between the Rocky Mountains and the Sierra it is confined almost entirely to towns along the railroads. The Biological Survey is without records of its presence in Nevada, Utah, Wyoming, or Idaho. The ability of the species to withstand extreme cold is proved by the fact that it flourished in latitude 78° 37′ north, on board the ship *Advance* of Doctor Kane's second Grinnell expedition during the two winters of icebound experience. It has been able to adapt itself also to the continuous low temperatures of cold-storage plants in many of our cities.

HISTORY OF THE BROWN RAT.

The early history of the brown rat is practically unknown. The species is generally supposed to be of Asiatic origin, but we have no positive knowledge as to its native country. Various modern writers have asserted that it came originally from Persia or India. But Mr.

[a] In the principal Asiatic seaports the brown rat is said to be often found closely associated with the other two forms.

W. T. Blanford states that the species is at present unknown in Persia, and that, as concerns India, the black rat is the generally distributed species, while the brown rat is found only along the coast and the navigable rivers.[a] This statement seems to imply that the latter is a comparatively recent immigrant into India. Early Greek and Roman writers make no mention of the rat, but it is possible that they knew the animal and included it in their references to mice.

As regards the time of the brown rat's introduction into Europe, we have two known facts. The species reached England from some eastern port about 1728 or 1729, and a little earlier it crossed the Russian frontier from Asia. Pallas, the naturalist and traveler, states that it first reached Europe from the east by way of the Volga, which river it crossed in 1727, and soon afterwards spread over the greater part of Russia.[b] In view of the statement of Blanford, already referred to, it is highly probable that previous to this migration the Asiatic home of the species was northward rather than southward of the mountain barriers of northern India. This view has been advanced by several naturalists and is further strengthened by the fact that the animal appears to flourish better in a temperate than in a tropical climate.

The brown rat is said to have first appeared in Paris in 1750. It was brought to the United States, probably from England, about the beginning of the Revolution, 1775. According to Audubon, it was unknown on the Pacific coast of the United States in 1851, although its introduction there must have occurred soon afterwards.

GENERAL DESCRIPTION.

The brown rat differs from the other two species in America in larger size, shorter head, more obtuse muzzle, smaller ears, and relatively shorter tail. The general color is grayish brown above and whitish below. The overhairs of the upper parts have black tips. The tail is usually shorter than the head and body combined, while in the other two species it is generally longer.

The black rat is usually of a sooty or plumbeous black color, paler on the underparts; while the roof rat is slightly grayer than the brown rat above and yellowish white on the feet and belly.

The skull of the brown rat shows well-marked differences from those of the other two species, but the skulls of the roof rat and the black rat are not readily distinguished from each other. Many zoologists regard the black rat as only a geographic race of the roof rat. The two forms interbreed freely.

The tame white rats of the bird stores are said to be mostly of the *Mus rattus* type; but albino and spotted specimens of the brown

[a] Fauna of British India, Mammals, p. 409, 1891.

[b] Zoographica Rosso-Asiatica, Vol. I, p. 165, 1831.

rat are not uncommon. The only albino rats in the collections of the National Museum and the Biological Survey are *Mus norvegicus*. Black, or melanistic, forms also of the brown rat are known.

The average measurements of adult specimens of the brown rat in the Biological Survey collections are as follows: Total length 415 mm. (16.4 inches); tail 192 mm. (7.1 inches); hind foot 43 mm. (1.7 inches). This rat sometimes attains a total length of 19 to 20 inches and has been known to weigh 24 to 28 ounces. The average weight of an adult is less than a pound.

ABUNDANCE OF RATS.

Few persons realize the vast numbers of rats that may inhabit a very small area. In cities, particularly, the animals swarm along river fronts and wharfs, as well as in sewers, stables, warehouses, markets, and other places where food is abundant. It is only when some of these harbors are demolished that the real numbers of the rats are discovered.

The number of rats that may harbor on an ordinary farm is astounding. In 1901 an estate of 2,000 acres near Chichester, England, was badly infested with the pests. They were systematically destroyed by traps, poisons, and ferrets. The total number destroyed under the personal supervision of the owner was 31,981; while it was estimated that tenants at the thrashing had killed fully 5,000 more. Even then the property was by no means free from rats.[a]

During the plague of rats on the island of Jamaica in 1833, the number killed on a single plantation in a year was 38,000. The injury to sugar cane on the island by the animals was at that time estimated at half a million dollars a year.[b]

An idea of the immense number of rats that may infest a country may be obtained from the report of the Indian Famine Commission presented to the English Parliament in 1881. An extraordinary plague of the animals infested the southern Deccan and Mahratta districts of India. The autumn crop of 1878 and the spring crop of 1879 were both below the average, and a great portion of the product was destroyed by rats. Rewards were paid for the destruction of the pests, and over 12,000,000 were killed.[c] While they were mostly of the black species, the illustration of abundance applies just as well to the brown rat, which is even more prolific.

HABITS OF RATS.

Close observation of the habits of wild rodents, especially of those chiefly nocturnal, is difficult. It is not surprising, therefore, that

[a] The Field (London), vol. 100, p. 545, 1902.
[b] New England Farmer, vol. 12, p. 315, 1834.
[c] British Medical Journal, September 16, 1905, p. 623.

information on the life history of an animal so common as the brown rat should be meager, nor that diverse opinions about its breeding should be current. When wild rats are kept in confinement, they rarely breed, and the conclusions as to their breeding have been inferred from observations of domesticated white rats.

BREEDING.

Observations show that climate and food supply greatly affect the rate of multiplication of rodents. The rat is no exception. It increases most rapidly in a moderately warm climate and with an abundant supply of food. Extremes of heat and cold retard its multiplication, decreasing both the number of litters produced in a year and the number of young brought forth at a time.

As already stated, the brown rat is more prolific than either of the two other species mentioned. The female brown rat generally has 12 mammæ—3 pairs of pectoral and 3 pairs of inguinal, although these numbers are by no means constant. The black rat and the roof rat have but 10 mammæ—2 pairs of pectoral and 3 pairs of inguinal, with but little tendency to vary. Records of actual observations confirm the deductions to be drawn from the above facts. At Bombay, India, during the recent investigations of the India Plague Commission, 12,000 rats were trapped and examined. The average number of embryos observed in pregnant brown rats was 8.1; the highest number, 14. The average for the black rat was 5.2; the largest number, 9.[a]

In temperate latitudes the average litter of the brown rat is probably considerably greater than the number above given. Instances of very large litters observed in England have been recorded in the Field (London). In two cases 22 and 23 young, respectively, were found in one nest, and in two other instances 17 and 19 were found in gravid females. A reliable observer residing in Washington, D. C., found 19 young rats in a single nest. The writer, on March 25, 1908, caught 6 rats in one trap, 3 of which were pregnant females, containing 10, 11, and 13 embryos, respectively. While we have hardly enough data on which to base definite conclusions for this latitude, we may safely conclude that the average litter is not less than 10.

The number of litters of young produced in a year by the brown rat is not definitely known, and probably varies with local conditions. Dehne's observations on white rats showed that in one instance an interval of only 71 days intervened between two litters from the same rat. A young female of the first litter gave birth to 6 young when she was only 103 days old.[b] Frank T. Buckland in his Curiosities of Natural History, relates that a white rat which he kept in

[a] Etiology and Epidemiology of Plague, p. 9. Calcutta, 1908.

[b] Brehm's Thierleben: Säugethiere, Vol. II, p. 353, 1877.

captivity gave birth to 11 young when only eight weeks old. As gestation in rats occupies three weeks, this animal must have bred when only five weeks old. Kolazy records instances of but 25 days between successive litters of well fed albino rats.[a]

The known facts concerning the reproduction of the brown rat in temperate latitudes may be briefly stated as follows: The animals breed from three to five times a year, each time bringing forth from 6 to 20 young. After a gestation period of 21 days, the female gives birth to her young in nests in underground burrows or under floors, stacks, lumber, wood piles, or other shelter. The young are blind and naked when born, but grow rapidly, and the females are capable of breeding when less than three months old.

If we assume that the animals breed three times a year and that the average litter is ten, and suppose that a pair and their progeny breed uninterruptedly at this rate for three years, with no deaths, the result would be as follows:

Theoretical results of three years' (nine generations) uninterrupted breeding of a pair of brown rats.

	Generation.								
	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
Number of pairs breeding	1	6	36	216	1,296	7,776	46,656	279,936	1,679,616
Number of young produced	10	60	360	2,160	12,960	77,760	466,560	2,799,360	16,796,160
Total number of individuals	12	72	432	2,592	15,552	93,312	559,872	3,359,232	20,155,392

Of course, such results never occur in nature. Apparently not nearly half the rats born are females; at least, among mature rats the males greatly predominate. Then, too, the life of young rats, as well as that of the old, is a continuous struggle for existence. Disease, the elements, natural enemies, the devices and cunning of man, and even cannibalism are continually at work to reduce their numbers.

MIGRATIONS AND INVASIONS.

Migrations of rats have often been recorded. Pallas narrates that in the autumn of 1727 the brown rat arrived at Astrakhan in southern Russia from the east in such numbers and in so short a time that nothing could be done to oppose them. They crossed the Volga in large troops. The cause of the migration was attributed to an earthquake; but since similar movements of this species often occur unattended by earth disturbance, it is probable that only the food problem was involved in the migration which first brought the brown rat to Europe.

[a] Verh. Zool. Botan. Gesel., Wien, pp. 731–734, 1871.

In nearly all countries a seasonal movement of rats from houses and barns to the open fields occurs in spring, and the return movement takes place as cold weather approaches. The movement is noticeable even in large cities.

But more general movements of rats often occur. In 1903 a multitude of migrating rats spread over several counties of western Illinois. They were noticed especially in Mercer and Rock Island counties. For several years prior to this invasion no abnormal numbers were seen, and their coming was remarkably sudden. An eyewitness to the phenomenon informed the writer that as he was returning to his home by moonlight he heard a general rustling in the field near by, and soon a vast army of rats crossed the road in front of him, all going in one direction. The mass stretched away as far as could be seen in the dim light. These animals remained on the farms and in the villages of the surrounding country, and during the winter and summer of 1904 were a veritable plague. A local newspaper stated that between March 20 and April 20, 1904, Mr. F. U. Montgomery of Preemption, Mercer County, killed 3,435 rats on his farm. He caught most of them in traps.[a]

In 1877 a similar migration occurred into parts of Saline and Lafayette counties, Mo.;[b] and in 1904, one came under the writer's observation in Kansas River valley. This valley for the most part was flooded by the great freshet of June, 1903, and for about ten days was covered with several feet of water. It is certain that most of the rats in the valley perished in this flood. In the fall of 1903 much of the district was visited by hordes of rats, which remained during the winter, and by the following spring had so increased in numbers that serious losses of grain and poultry resulted.

No doubt the majority of the so-called migrations of rodents are in reality instances of unusual reproduction or of enforced migration owing to lack of food. In England a general movement of rats inland from the coast occurs every October. This is closely connected with the closing of the herring season. During the fishing, the rodents swarm to the coast, attracted by the offal left from cleaning the herring; and when this food supply fails, they hasten back to the farms and villages.

In South America periodic plagues of rats have taken place in Parana, Brazil, at intervals of about thirty years, and in Chile at intervals of from fifteen to twenty-five years. These plagues in the cultivated lands follow the ripening and decay of the dominant species of bamboo in each country. The ripening of the seed furnishes for two or more years a favorite food for rats in the forests, where

[a] Moline (Ill.) Evening Mail, April 25, 1904.

[b] Forest and Stream, vol. 8, p. 380, July 12, 1877.

the animals multiply greatly; when this food fails they are forced to the cultivated districts for subsistence. In 1878 almost the entire crops of corn, rice, and mandioca in the State of Parana were destroyed by rats, causing a serious famine.[a]

An invasion of black rats (*Mus rattus*) in the Bermuda Islands occurred about the year 1615. In a space of two years they had increased so alarmingly that none of the islands were free from them. The rodents devoured everything which came in their way—fruit, plants, and even trees—so that for two years the people were destitute of bread. A law was passed requiring every man in the islands to set 12 traps. In spite of all efforts, the animals increased, until they finally disappeared with a suddenness which could have resulted only from a pestilence.[b]

FOOD OF RATS.

The brown rat is practically omnivorous. The statement applies as well to the black rat and the roof rat. Their bill of fare includes seeds and grains of all kinds, flour, meal, and food products made from them; fruits and garden vegetables; mushrooms; bark of growing trees; bulbs, roots, stems, leaves, and flowers of herbaceous plants; eggs, chicks, ducklings, young pigeons, and young rabbits; milk, butter, and cheese; fresh meat and carrion; mice, rats, fish, frogs, and mussels. This great variety of food explains the ease with which rats adapt themselves to almost every environment.

Experiments show that the average quantity of grain consumed by a full-grown rat is fully 2 ounces daily. A half-grown rat eats about as much as an adult. Fed on grain, a rat eats 45 to 50 pounds a year, worth about 60 cents if wheat, or $1.80 if oatmeal. Fed on beefsteaks worth 25 cents a pound, or on young chicks or squabs with a much higher prospective value, the cost of maintaining a rat is proportionately increased. Granted that more than half the food of our rats is waste, the average cost of keeping one rat is still upward of 25 cents a year.

If an accurate census of the rats of the United States were possible, a reasonably correct calculation of the minimum cost of feeding them could be made from the above data. If the number of rats supported by the people throughout the United States were equal to the number of domestic animals on the farms—horses, cattle, sheep, and hogs—the minimum cost of feeding them on grain would be upward of $100,000,000 a year. To some such enormous total every farmer, and indeed every householder who has rats upon his premises, contributes a share.

But, as will be shown later, the actual depredations of rats are by no means confined to what they eat. They destroy fully as much

[a] Nature, vol. 20, p. 65, 1879.

[b] Popular Science Monthly, vol. 12, p. 376, June, 1878.

grain as they consume, and they pollute and render unfit for human consumption a much larger proportion of all other food materials that they attack. In addition, the damage they do to property of other kinds is often as great as that done to food supplies.

DAMAGE BY RATS.

But few attempts have been made to collect statistics of damage done by noxious animals in America. The reported items of loss are so scattered and fragmentary that no accurate estimate of their amount is possible. In some parts of Europe, where agricultural holdings are small and minute economies prevail, such statistics are sometimes collected. Thus in Russia returns of the losses from predatory Carnivora in the various provinces are published annually.

A few estimates of the amount of losses from rats in foreign countries have been published. In Denmark they have been reported as amounting to 15,000,000 francs ($3,000,000) yearly.[a] In France in 1904 the total losses from rats and mice were estimated at 200,000,000 francs (nearly $40,000,000).[b] The German Ministry of Agriculture, in a circular addressed to various subordinate chambers of agriculture, states that the people of Germany suffer an annual loss through the agency of the rat of at least 200,000,000 marks ($50,000,000). Sir James Crichton-Browne, of the English Incorporated Society for the Destruction of Vermin, says that the damage done by the rat in Great Britain and Ireland "in its rural activities, to say nothing of what it does in towns and in connection with shipping, is £15,000,000 (about $73,000,000) per annum."[c]

The principal ways in which rats inflict losses in the United States are discussed under the various subheadings below.

GRAINS.

Cultivated grains may be regarded as the favorite food of rats. The animals dig the seed from the ground as soon as sown, eat the tender sprouts when they appear, and later feast upon the maturing crop. After harvest they attack grain in shock, stack, and mow, and when thrashing is over, in crib, granary, elevator, mill, and warehouse. The toll thus taken varies with the numbers of the rodents, and in some places amounts to a considerable percentage of the crop. In exceptional cases entire crops have been ruined by rats.

Indian corn.—On the whole this crop suffers greater injury from rats than any other in the United States. Besides depredations on newly sown seed, the animals attack the growing grain when in the

[a] Dr. Adrian Loir in Jour. d'Agri. Tropicale, vol. 3, p. 369, December 31, 1903.
[b] Jour. Board of Agri., Great Britain, vol. 2, p. 50, 1904.
[c] Jour. Inc. Soc. Dest. Vermin, vol. 1, p. 74, October, 1908.

milk stage. They climb the upright stalks and often strip the cobs clean of grain. The writer has seen whole fields of corn so destroyed, and in many cases has observed parts of fields amounting to several acres practically ruined. A writer in the American Agriculturist reported an instance in which rats destroyed three-fourths of the corn on 13 acres of land.[a] In 1905 a large portion of the crop grown on the Potomac flats, near Washington, was destroyed by rats (Plate II). The crops for 1906 and 1907 were saved by the use of traps and poisons.

Corn in the field, if left standing long in the shock, is liable to injury from rats. A pair of the animals will soon ruin an entire shock, destroying both grain and fodder. Such damage is sure to take place if the corn is near hedgerows, embankments, drains, or other harbors where rats are abundant; but sometimes the shocks themselves furnish shelter for the animals.

Rats often damage corn in cribs. Too frequently these receptacles for grain are built close to the ground, and rats live under the floor. They often perforate the wooden barrier and thereafter have free access to the grain. They shell the corn, eating the softer part of the kernel and wasting much more than they consume. They carry the grain to subterranean burrows and bring up into the crib moist soil, which induces mold in the corn and leaves much unfit for market or for feeding stock. A correspondent in Arkansas once wrote to the secretary of the American Institute, stating that fully half his corn was destroyed by rats after it was placed in the crib.[b]

A farmer living near Grand River, Iowa, relates the following experience:

"We had about 2,000 bushels of corn in 3 cribs to which rats ran, and they ate and destroyed about one-fourth of the corn. Much of it was too dirty to put through the grinder until it had been cleaned an ear at a time. All the time we were poisoning and trapping the rats. We killed as high as 300 rats in two days and could hardly miss them. They destroyed more than enough corn to pay taxes on 400 acres of land." [c]

The foregoing are extreme cases, but too often farmers lose a considerable portion of the crop by rat depredations. A little forethought and care in constructing or protecting the cribs would prevent such losses.

Small grains.—The rat in America has usually been considered a house and barn pest, and little notice has been taken of its destructiveness in fields. As a matter of fact, in some localities brown rats, and also common house mice, swarm in the fields, especially in summer.

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[a] Am. Agr., vol. 33, p. 300, 1874.

[b] Trans. Am. Inst., 1866–67, p. 347.

[c] Mo. Valley Farmer, April, 1907.

FIG. 1.—A CORNFIELD DEVASTATED BY BROWN RATS.

FIG. 2.—A SINGLE CORNSTALK RUINED BY BROWN RATS.

The permanency of the rat's stay in any place is merely a question of food supply. As long as cribs and stables furnish plenty, rats remain in them, but in summer the harvest field and the wheat stacks prove equally if not more attractive, and rats roam far afield.

The small grain crops—wheat, rye, barley, oats, and the like—during growth and until they leave the farmer's hands are constantly dwindling in quantity through inroads made upon them by rats, and these animals continue to prey upon them at every stage of their progress from the field to the consumer. Rats take toll not only from the portion set apart for human food, but even from feed box and manger, as well as from hog trough and outdoor field lot. Bran and chopped grains are as acceptable to rats as whole grain.

The destruction of feedstuffs by rats is a serious loss not only on the farm but in almost every city and village in the whole country. Often through carelessness or the indifference of servants, the bin or barrel in which feed is kept is left uncovered, and rats fairly swarm to the nightly feast. In some cases investigated in Washington, D. C., the loss was equal to 5 or 10 percent of the grain bought. A grocer was buying feed for two horses and several hundred rats; the horses were fed at regular intervals, the rats nearly all the time. In the cases of establishments keeping from fifty to a hundred horses, the loss of feed in the course of a year often amounts to a large item.

Rats are very fond of malt, and in malt houses and breweries constant watchfulness is necessary to prevent losses. Mills, elevators, and warehouses in which grain and feedstuffs are stored are likewise subject to invasions of the animals. Also the destruction of sacks, barrels, and bins is a large item of loss.

Rice.—Rats and mice injure rice fields in the South. The brown rat burrows freely in the dikes and is usually the most destructive species, although the introduced roof rat, the native rice rat (*Oryzomys*), and the native cotton rat (*Sigmodon*) also are injurious in some localities. A letter from Alfred Chisholm, of Savannah, written to Doctor Merriam about twenty years ago, gives some details of the abundance of rats—probably several species—in the Georgia rice fields. Mr. Chisholm says:

> Rats do almost if not quite as much damage [to rice] as birds. * * * It is a matter of fact that Col. John Screven had killed on his Proctor plantation (400 acres of rice lands) over 17,000 rats; and on the Delta plantation (1,000 to 1,200 acres) there were killed by actual count 30,000. These rats were killed during the winter and spring of the same year. During the "stretch" flow, the rats will swim out into the fields from their holes in the dikes and eat every grain of rice left exposed, their depredations being carried on mostly at night.

Arsenic was used to poison the rodents, some planters having each purchased from 50 to 100 pounds of the poison.

Sugar cane.—In nearly all countries that produce cane sugar the planters experience serious loss from rat depredations. The animals cut down and eat the ripening canes, usually selecting a fresh one at each attack. Recent complaints of serious losses to cane planters in Porto Rico and Louisiana have been received by the Biological Survey.

POULTRY AND EGGS.

The depredations of rats upon poultry are a source of serious loss. The amount of damage varies with the abundance of rats and the care taken to exclude them from the poultry yard; but the total for the entire country is always great. The loss of poultry due to rats is probably greater than that inflicted by foxes, minks, weasels, skunks, hawks, and owls combined. Since harm is usually done at night and the actual culprit is unseen, conclusions as to the identity of the marauder are often mere guesswork, and much of the damage done by rats is blamed upon other animals. Not long since, in a published account of depredations on poultry, the damage was attributed to a skunk. The statement was made that both eggs and young chicks were taken from under a sitting hen without disturbing her. This is a trick peculiar to the rat, and it is evident that a mistake was made as to the identity of the thief.

Where rats are numerous in springtime, they often prey upon young chicks, capturing them in the nest and in and around the coops. I have known them to take nearly all the chicks on a large poultry ranch, and, in the same neighborhood and over a large territory, to destroy nearly 50 percent of the season's hatching. Young ducks, turkeys, and pigeons are equally liable to attack, and where rats are numerous are safe only in rat-proof coops.

A writer in a western agricultural paper states that in 1904 rats robbed him of an entire summer's hatching of three or four hundred chicks.[a] A correspondent of another journal says, "Rats destroyed enough grain and poultry on this place in one season to pay our taxes for three years."[b] When it is remembered that the poultry and eggs produced each year from the farms of the United States have a value of over $600,000,000, it will be seen that even a small percentage of loss aggregates a large sum.

Rats destroy also many eggs both on farms and in cities. Fresh as well as incubated eggs are eaten by these rodents. Commission men and grocers complain much of depredations upon packed eggs. Those at the top of a case are broken by these animals, and parts of the yelks run down and stain the unbroken ones. Often, however, rats carry away eggs without breaking them, and display much ingenuity in getting them over obstacles, as up or down a stairway.

[a] Homemaker (Des Moines, Iowa), May 27, 1907.
[b] Mo. Valley Farmer, April, 1907.

On a level surface the rat rolls the egg before him, but he can easily carry it between a paw and his neck and chin, while going upon three legs.

A commission merchant in Washington relates that he once stored in his warehouse 100 dozen eggs in a wooden tub with a lid of boards nailed on. Rats gnawed a hole through the tub at the top and carried away all but 28½ dozen, leaving no shells or stains to show that any had been broken.

Rats cause much annoyance and loss to poultrymen by their destruction of feed put out for fowls.

Rats are very destructive to tame pigeons, attacking especially young squabs, but destroying eggs also. They often show great cunning in finding entrances to the cages. A fancier residing in Washington, D. C., missed many of his squabs and was satisfied that the only opening by which an animal could enter was the exit at the top of the flying cage. He closed the opening and set a trap there, in which he caught a large rat. The animal had climbed the wire netting on the outside and descended it on the inside to reach the pigeons.

GAME AND OTHER BIRDS.

The rat is a most serious pest in game preserves. The propagation of game birds, both native and introduced, is now a promising industry in the United States. The rat has already proved itself a foe by destroying both eggs and young of pheasants. Abroad, the game preserver regards the rat as the worst enemy of game. A writer in Chambers' Journal says:

> In a closely preserved country at the end of an average year the game suffers more from the outlying rats of the lordship than from the foxes and the mustelines together. The solitary rats, whether males or females, are the curse of a game country. They are most difficult to detect; for in a majority of cases their special work is supposed to be done by hedgehog, weasels, or stoat.[a]

Another writer says:

> There is little doubt that of late years the worst vermin with which the generality of preservers have had to contend has been the rat. It has increased largely in numbers and in some districts become quite a plague, despite the extraordinary efforts made to deal with its ever-increasing depredations. It is unnecessary to speculate upon the probable cause of this remarkable increase. It is due entirely to the neglect of farmers, preservers, and others to adopt adequate means to deal with the pest.[b]

Our native game birds in the wild state are less subject to rat depredations than imported species. The nests of ruffed grouse are made in woodlands, which rats seldom invade The prairie hen and related species generally nest in places remote from the usual haunts of rats. The quail, or bobwhite, however, often selects a nesting site within the summer range of rats, and many a quail's egg reaches the maws of these animals.

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[a] Chambers' Journal, vol. 82, p. 64, January, 1905.

[b] Practical Game Preserving, by Wm. Carnegie ("Moorman"), p. 349, 1906.

Nests of wild ducks, woodcock, and other marsh birds are frequently destroyed by rats. Terns have been driven from their nesting grounds and entire colonies broken up in this way. Professor Mayer, of the Department of Marine Biology, Carnegie Institution of Washington, wrote, May 3, 1908, that rats had almost exterminated the colony of least terns on Loggerhead Key, Tortugas Islands. They destroyed also nearly all the gulls' and other birds' eggs laid on the key. A more recent letter from Professor Mayer states that, through systematic use of traps and poisons, all the terns hatched during the summer of 1908 were saved.

Rats eat also the eggs of nearly all kinds of ground-nesting song birds, and the real offender is seldom even suspected. Crows, jays, snakes, and skunks get much of the blame for the destruction; and while some of them share in the guilt, rats are, after all, the most serious enemies of song and game birds.

FRUITS AND VEGETABLES.

The damage done by rats to fruits and vegetables while stored in cellars and pits is well known. If any garden vegetable or common fruit is immune to their attacks, the fact has thus far escaped notice. But the extent to which the animals prey upon fruits and vegetables before they are harvested is not generally known. Rats attack ripe tomatoes, melons, cantaloupes, squashes, pumpkins, sweet corn, and many other vegetables in the field, and the depredations are often attributed to rabbits. Often both rats and rabbits take toll from the same field or garden, and the work of the former is unsuspected.

Rats are fond of nearly all small fruits, picking them up from the ground and even climbing grape vines, raspberry or blackberry canes, and currant or gooseberry bushes to obtain the ripe fruit.

The brown rat often feeds upon ripe apples, pears, cherries, and other fruits that have fallen to the ground, but it has been known to climb even to the extremities of the branches to obtain ripe apples.[a] Capt. R. R. Raymond, U. S. Army, records the following:

> Just west of old Fort Clinton, at West Point, N. Y., there was, about twenty-five years ago, a deep hollow, in the bottom of which several cherry trees grew. The hollow was used as a dump and was gradually filled level, but at the time mentioned was the home of a great many Norway rats. I often visited the hollow for cherries and frequently met rats in the trees on the same errand as myself.[b]

Dr. L. O. Howard, Chief of the Bureau of Entomology, Washington, D. C., informs the writer that during a single afternoon he shot 28 rats from the branches of a cherry tree growing in the heart of the city. The rats were feeding on the ripe fruit.

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[a] The Field (London), vol. 78, p. 660.

[b] Shields' Magazine, vol. 5, p. 123, 1907.

The brown rat is less of a climber than either the roof rat or the black rat; but in warm countries all three climb trees to a greater extent than in the north. Indeed, it is probable that one of the chief reasons why the brown rat has not been able to displace the others within the Tropics lies in the fact that they are more expert climbers. Both the roof rat and the black rat often nest in trees in hot countries, and as a matter of course feed much upon fruits. During the present attempts to abate the rat nuisance in Honolulu, Hawaii, about one-third of the rats taken have been shot from trees. While all four of the cosmopolitan species of *Mus* are common in Hawaii, those shot are chiefly the roof rat and the black rat.

Among the tropical fruits eaten by rats are oranges, bananas, figs, dates, cocoanuts, and especially the pods of cacao, from which chocolate is manufactured.

Attempts to grow dates in the southwestern United States have shown that thus far a native rat (*Sigmodon*) is the worst enemy of the date in America, but it is probable that the introduced rat will soon find its way into the plantations, displace the native species, and prove a more serious foe.

In many lands rats have proved to be enemies of the coffee-growing industry. A correspondent of The Field (London) writes to that journal as follows: "A coffee plantation in which I have an interest in Central America has recently been infested with rats to such an extent that life is almost unbearable. The place has an extent of several thousand acres, part of which is forest land, and I have noticed the branches of the bigger trees full of the pests in the daytime."[a]

Grapes grown under glass are peculiarly subject to attacks of rats. This is especially true in situations where the surrounding buildings are old and dilapidated.[b]

Rats often destroy fruits and vegetables in transit on steamboats. Tomatoes, cucumbers, sweet potatoes, bananas, oranges, grape fruit, peanuts, and other products shipped by water from the South reach their destination in northern markets with a heavy percentage of damage. Steamship companies usually ignore the claims of shippers or receivers for shortage from this cause; and their legal responsibility has not been established. In view of the practicability of destroying rats on steamers by means of fumigation, and the slight cost of building rat-proof compartments for holding the produce, it would seem that this form of loss should be entirely avoided.

MERCHANDISE IN STORES AND WAREHOUSES.

Next to the loss on grains, the largest item of loss due to rats is on miscellaneous merchandise in stores, markets, and warehouses.

[a] A. H. G., in The Field (London), vol. 107, p. 787, May 6, 1905.

[b] Gardener's Chronicle, 1861, p. 986.

Food materials of every description are subject to attack, but the destruction of dry goods, clothing, books, leather goods, and so on, is equally serious. Many are gnawed to secure material for nests; but books and pamphlets, especially the newly bound, furnish food in the glue and paste used in the binding. Leather of certain kinds is peculiarly attractive to rats. Articles made of kid leather are often destroyed, gloves and shoes especially. Shoes made of ordinary leather are seldom injured unless they have cloth tops. Rats often gnaw old harness, attracted probably by the salt left from perspiring horses. New harnesses are seldom injured, except collars and cruppers, to which rats are attracted by the straw or flaxseed in the stuffing. A harness dealer in Washington reports a recent loss of over a hundred new cruppers, valued at about $90.

Lace curtains, silk handkerchiefs, linens, carpets, mattings, and other dry goods in large stores are much damaged by rats; some for the starch which furnishes food, others for nesting materials. Stuffs that have been soiled by rats in passing over them are often rendered unsalable.

Nearly all large dry goods and department stores have heavy losses from rats, amounting in some instances to several hundred dollars a year, in spite of unremitting efforts to destroy the animals. Grocers, druggists, confectioners, and other merchants have similar experiences. Many of them expend large sums every year fighting the pests. Most of our large cities have several so-called expert rat destroyers who operate with dogs, ferrets, poisons, and other means, and who have a large clientage among merchants and hotel managers. These pay yearly stipends of various sums, from $100 to $600, to the rat catchers to keep their premises free from rats and mice. While the stipulated service is not often performed in full, the clients usually regard the expenditures as economical.

FLOWERS AND BULBS.

Rats are recognized pests of the greenhouse and the plant-propagating pit. They attack seeds, bulbs, leaves, stems, and flowers of growing plants. Of flowering bulbs, the tulip suffers most. Hyacinths also are eaten, while narcissus bulbs are apparently immune to attack. Doubtless this is owing to the slightly poisonous qualities of narcissus.

During the winters of 1904–5 and 1905–6 rats destroyed many of the tulips grown on the Potomac flats near Washington. Sometimes several hundred bulbs were taken in a single night. Hyacinths were injured to a less extent. Traps and poisons made heavy inroads upon the numbers of rats, and probably about 60 percent of the tulips and 90 percent of the hyacinths were saved each season.

Rats attack flowering plants in the greenhouse or conservatory as well as house plants elsewhere. They eat pinks, carnations, and

roses, cutting the stems off clean, and denude geraniums of both flowers and leaves. In stores and markets infested by rats carnations can not be left exposed without being eaten. Next to carnation growers, the growers of chrysanthemums are the greatest losers, for rats attack the choicest blooms even in exhibition rooms.

FIRES CAUSED BY RATS.

In the museum of the Royal United Service Institution, Whitehall, London, some years ago, a rat nest was exhibited bearing the following note:

> Rat's nest and young. This nest was set on fire by a lucifer match ignited by the old rat as she worked it into her nest. A fire was nearly caused thereby on H. M. S. *Revenge*.—Lieut. A. H. Gilmore, R. N.[a]

It is generally believed that rats and mice cause fires by igniting matches with their teeth. The testimony of chiefs of fire departments and adjusters of fire-insurance claims confirms this belief, and many specific instances have been given of fires caused in this way. A fire which resulted in the partial destruction of the Sultan's palace at Scutari, Asia Minor, in 1856, had such an origin. During 1907 the fire department of Washington, D. C., gave a similar explanation of a fire which seriously damaged a large store and its contents.

Manufacturers of matches often dip them in paraffin to protect the phosphorus. The paraffin is attractive to rats and mice, and the matches are often carried under floors and behind partitions, where they are subsequently gnawed. Paper and other combustible materials collected by the animals add to the danger of fires. Moreover, since the heads of phosphorus matches contain from 14 to 17 percent of phosphorus, it does not require actual gnawing by rats to ignite them. Hot weather, excessive heat from furnaces, or friction of any kind may effect the same result as the teeth of rats, when the matches have been carried into a nest made of combustibles.

Fires in mills and warehouses have been traced to the spontaneous ignition of oily and fatty rags or waste carried under floors by rats or mice. Cotton mills are said to be peculiarly subject to fires from this cause.

Phillip's warehouse, Church street, London, was twice set on fire and damaged by reason of gas leaks. In both instances the lead gas pipe leading to the meter had been eaten through by rats, and the escaping gas was accidentally set on fire by workmen who were searching for the leak.[b] In a similar instance of gas leak caused by rats in a London private residence, no fire resulted, but a sleeping family of four persons narrowly escaped death by asphyxiation. An inspector in the employ of the Washington Gas Light Company recounts a

[a] Hardwicke's Science Gossip, vol. 5, p. 142, 1869.
[b] Hardwicke's Science Gossip, vol. 10, p. 73, 1874.

similar instance in that city where pipes were gnawed by rats, but fortunately it occurred when the inmates were awake.

The most common way in which rats cause fires is by gnawing away the insulating covering from wires used in electric lighting, where the wires pass under floors or inside of partitions. The insulating materials are used for nests, which rats often build of combustibles placed in contact with the naked wires. Insurance companies, a few years ago, estimated the fire loss in the United States due to defective insulation of wires at $15,000,000 yearly; and since rats and mice are the chief agents in impairing the insulation after the wires are in place, a large part of the above sum must be charged to these animals.

Rats often do mischief by gnawing the insulating covering of telephone wires to obtain the paraffin which it contains. The accompanying illustration (fig. 1) is from a photograph of wires gnawed by

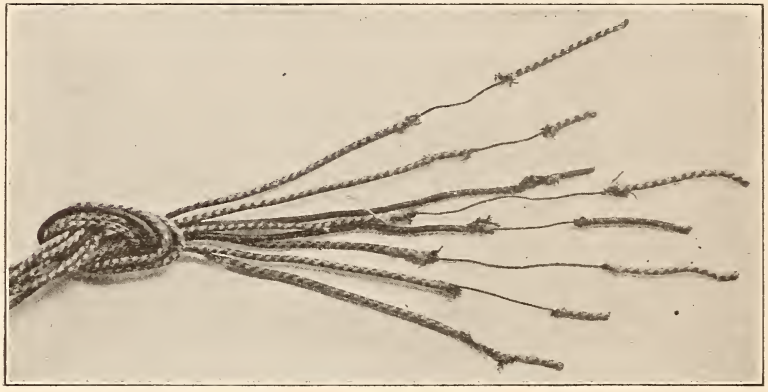

FIG. 1.—Telephone wires gnawed by rats.

rats August 20, 1908, where these wires passed through a partition in rooms occupied by the Biological Survey.

DAMAGE TO BUILDINGS AND FURNITURE.

The damage to houses and furniture by rats constitutes a large item. They burrow under foundations or through the plaster in a stone wall and admit streams of water that eventually weaken or undermine the structure itself. They seem to be able to penetrate almost everything except stone, brick, cement, glass, and iron. They gnaw into a grain bin, or through a wainscoting, a floor, or a door in a single night. In the same way they enter chests, wardrobes, bookcases, closets, barrels, and boxes for the stores within. Almost every old dwelling in the country bears abundant evidence of its former or present occupancy by rats. Often depreciation in value of houses and furniture is due largely to marks left upon them by rats—marks that paint and varnish can not hide.

Damage to dwellings is even more serious. The decay of sills and floors is often hastened by contact with wet soil brought up by rats. Rats gnaw through lead pipes or wooden tanks to obtain water, and sometimes before the leak is discovered, ceilings, wall decorations, and floor coverings are flooded and practically ruined. All this is waste of a tangible kind and a constant drain on the prosperity of the people.

MISCELLANEOUS DAMAGE.

Like the muskrat, the common brown rat burrows into embankments and dams, often causing extensive breaks attended with serious loss. At State and National fish hatcheries rats cause much trouble by burrowing into embankments and gnawing through wooden tanks.

Rats often gnaw the hoofs of horses until the feet bleed. Several keepers of livery stables and dealers in horses in Washington, D. C., have had animals thus injured. Brushing the hoofs with dilute carbolic acid is a preventive.

Rats have been known to kill young lambs and pigs and to attack very fat hogs and eat holes in their bodies, causing death. Farrowing sows have been killed by rats gnawing their teats until blood poisoning resulted.[a] In a similar way, they sometimes attack the ears of pigs and shoats and cause their death by the gradual bloodletting.

Many accounts of rats attacking human beings have been published. The modern newspaper reporter seems to delight in harrowing tales of this character, most of which are the product of fertile imagination. Rats will fight if closely cornered or made desperate by lack of food, but many persons already have an unreasoning fear of the animals, which ought not to be intensified by exaggeration.

Rats often carry away valuable articles to use in constructing their nests. The following were found in a single nest: Three bed-room towels, 2 serviettes, 5 dust cloths, 2 pairs linen knickerbockers, 6 linen pocket handkerchiefs, and 1 silk handkerchief. The same rat had carried away and stored near its nest for food 1½ pounds sugar, a pudding, a stalk of celery, a beet, carrots, turnips, and potatoes.[b]

Rats in London warehouses and on shipboard do much damage to ivory in bulk. They gnaw the tusks, usually selecting the freshest and most valuable specimens.

A form of loss by rats once common on ships is not so prevalent now, owing to the more common use of metal in the construction of tanks and bulkheads. This was the perforation of wooden partitions and the damaging of merchandise and ship stores by water.

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[a] Moline (Ill.) Evening Mail, April 25, 1904.

[b] The Field (London), vol. 77, p. 46, 1891.

The extensive use of tinned provisions has also greatly diminished the losses to ship stores.

The destruction of mail sacks and their contents by rats during transportation on ships and at railway stations is a common source of loss. Grain sacks and bagging of all kinds are injured by rats more than by wear.

EXTENT OF DAMAGE BY RATS AND MICE IN CITIES.

During January and February, 1908, the writer personally interviewed about 500 business men in Washington and more than 100 in Baltimore for the purpose of securing data upon which to base an estimate of the probable amount of injury done to property by rats and mice in cities. The persons interviewed included dealers in various kinds of merchandise, feeders of horses, managers of hotels and restaurants, and manufacturers. The inquiries included all sections of the two cities and small dealers as well as large. Estimates of losses experienced during the calendar year 1907 were asked for, and, while some of the responses were mere guesses, the losses reported furnish a fairly reliable basis for averages.

Of 499 firms interviewed in Washington, 71 reported no losses, 83 were unable to give estimates, and 345 reported damages aggregating $36,100. Of the firms seen, no account was taken of about two score alien dealers in groceries or fruits who, probably because of fears of health inspection, would not admit that they were troubled by rats or mice, although evidences of rat damage were plainly visible in their stores.

The whole number of firms in the city engaged in the lines of business investigated is about 4,500. If those whose reports were considered had average losses, the total for the city would be upward of $300,000; but, to avoid exaggeration, a probable average per firm in each kind of business was calculated separately. With reasonable reductions made in this way, the total loss on merchandise in the city was estimated at $193,615. The several lines of trade not included would increase the total for the entire city to more than $200,000.

Besides the above, great loss is experienced in injury to buildings—public, business, and private. The loss on furniture and fixtures also is great. If we estimate the losses in private residences—including personal property and food destroyed, depreciation of property, and the cost of traps, poisons, cats, dogs, and other means of fighting rats—as averaging $4 for each residence, the total amounts to $200,000 a year also. It is conservative to place the entire yearly loss to the people of Washington from rats and mice at $400,000.

Inquiries in Baltimore developed the fact that, in proportion to amount of business and population, the damage from rats and mice is fully as great as in Washington. The portion of Baltimore rebuilt

since the great fire of February, 1904, has been reasonably free from rats until the past year. However, many of the large modern buildings erected in the burnt district are now infested with rats. Losses from rats in the markets of Baltimore are less than in those of Washington, not because rats are scarcer, but because Baltimore enforces more stringent regulations as to the storing of goods and the arrangement of fixtures in the stalls. Based on its population and commercial importance as compared with Washington, the total losses exceed $700,000 a year. If similar conditions hold for all cities of over 100,000 inhabitants in the United States, as they probably do, depredations of rats and mice in these centers of population entail a direct loss to the residents amounting to the enormous sum of $20,000,000 annually.

RATS AND PUBLIC HEALTH.

The most serious charge against rats grows out of their relation to human health. It is now positively known that rats are chiefly responsible for the spread of bubonic plague, a malady which, in spite of modern methods of fighting it, has within the past dozen years destroyed over 5,000,000 human beings in India alone. During 1907 the deaths from plague in India were 1,200,000, and by May, 1908, the present epidemic, which started in China in 1894, had invaded all the continents and infected 51 countries of the world. The identity of plague in man with plague in the rat was proved some years ago, but the particular means by which the disease is transmitted from rat to rat and from rat to man was not clearly understood until recently. The fact that fleas carry the infection was set forth positively as early as 1902, but the conclusions of the India Plague Commission have finally removed all doubt upon the subject. The results of two years of exhaustive research were recently published in a pamphlet which thus summarizes the conclusions concerning bubonic plague:

1. Bubonic plague in man is entirely dependent on the disease in the rat.
2. The infection is conveyed from rat to rat and from rat to man solely by means of the rat flea.
3. A case of bubonic plague in man is not in itself infectious.
4. A large majority of plague cases occur singly in houses. When more than one case occurs in a house the attacks are generally simultaneous. [This proves that there is no soil infection.]
5. Plague is usually conveyed from place to place by imported rat fleas which are carried by people on their persons or in their baggage. The human agent not infrequently himself escapes infection.
6. Insanitary conditions have no relation to the occurrence of plague, except in so far as they favor infestation by rats.
7. The nonepidemic season is bridged over by acute plague in the rat, accompanied by a few cases amongst human beings.[a]

[a] Etiology and Epidemiology of Plague, p. 93. Calcutta, 1908.

Experiments were made with two species of rat fleas, both of which were found to carry the infection. Probably all kinds of rat fleas transmit plague, while those that commonly infest dogs, cats, and man do not.

The conclusions of the Plague Commission had already been practically accepted by medical men in most parts of the world, and recent outbreaks of plague were followed by active measures for the destruction of rats. In India, as early as 1905, the authorities of the United Provinces (Agra and Oudh) began a persistent war upon the animals. Rewards were offered for killing rats, and traps were given to the people. In the four centers of population—Agra, Allahabad, Bareli, and Badaun—a total of 416,403 rats were killed before the close of the first year.[a] In Athens, Odessa, Oporto, Glasgow, and other European cities systematic, but on the whole unsuccessful, efforts were made to exterminate these animals.

Similar attempts to get rid of rats have been made since September, 1907, in some of the Pacific ports of our own country, particularly in San Francisco, where up to February, 1908, 77 deaths from plague occurred. Traps, poisons, bounties, and other means were employed to reduce the number of rodents. During the first four months of warfare under the direction of the United States Marine-Hospital Service about 130,000 of the animals were destroyed in San Francisco and vicinity. In the early months of 1908 the work of destruction was stimulated by increased bounties, and for a time the number of rats killed averaged about 7,000 per week. Up to May, 1908, 278,000 rats were captured in the city and it was estimated that half a million had been poisoned.

From May, 1908, to January 1, 1909, 115,869 rats were trapped and 9,797 were found dead in San Francisco. On an average, over 140,000 poisoned baits per week were placed, but as a matter of course the number of dead rats discovered was only a small percent of the total number killed by poison. The last rat found infected with plague bacillus was taken October 23, 1908, but no human cases of the disease have occurred in the city since January, 1908.

In Honolulu, Hawaii, active operations against rats have been reported since May 23, 1908. During the 30 weeks ending December 12, 1908, 20,288 rats were trapped and 3,528 shot from trees in the city. None of those examined was infected with plague bacillus.

But rats disseminate diseases other than bubonic plague. Trichinosis among swine is probably perpetuated entirely by rats. The occurrence of trichinæ among herbivorous animals is very rare, and in the hog can result only from its eating the flesh of animals infested with the parasite. The only two animals of the farm known to be

[a] Report on Plague in the United Provinces by Maj. Chator White, 1906.

subject to the parasite are the rat and the hog itself. Pork becomes trichinous, then, only when swine eat the flesh of infested rats or hogs. Country slaughterhouses, where rats are abundant and swine are fed on offal, are the chief sources of trichinous pork.[a]

A writer in The Spectator (London) states that septic pneumonia is sometimes the result of drinking water from shallow wells in which rats have been drowned and their bodies left to decay. He adds further that rats are "also disseminators of every kind of disease which can be conveyed into and from drains; for of all highways a rat loves a drain the best."[b] What visions of typhoid, scarlet, and malarial fevers, diphtheria, and other malignant diseases are aroused by such a statement! It is probable that many disease germs adhere to rats' feet and are thus carried to places where they threaten human health. Ptomaines are said to be sometimes conveyed to meats or other human foods in this way. On the whole, hygienic considerations furnish the strongest argument for the extermination of rats.

UTILITY OF THE RAT.

Except that to a limited extent rats act as scavengers, they render no important service to man. In former times, doubtless, their work as scavengers in cities was of considerable value, but modern methods of garbage disposal make this service insignificant.

MEANS OF REPRESSING RATS.

It is not creditable to our civilization that a creature so noxious as the rat should continue to flourish. The fact that it lives in surroundings of dirt, disorder, and waste, while it preys on the best of our productions, makes its constant increase a matter for chagrin. The animal has developed such an extraordinary degree of sagacity under persecution that attempts to exterminate it have been largely wasted. The failure of these efforts has not been due to lack of effective methods so much as to negligence and the absence of concerted action. Besides, as already stated, we have rendered our work abortive by continuing to provide subsistence and hiding places for the rat. When once these advantages are denied to the animals, persistent and concerted application of the best methods of destroying them will prove far more effective.

The more important means of fighting rats are considered under five captions: (1) Natural enemies of the rat, (2) rat-proof construction of buildings, (3) keeping food from rats, (4) driving away rats, (5) destroying rats.

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[a] Circular 108, Bureau of Animal Industry, p. 1, 1907.

[b] The Spectator, vol. 95, p. 603, October 21, 1895.

NATURAL ENEMIES OF THE RAT.

The extent to which predatory mammals and birds feed upon rodents should be more generally understood. Probably the greatest factor in the increase of rats, mice, and other destructive rodents in the United States has been the persistent killing off of the birds and mammals that prey upon them. Too often the slaughter is based upon ignorance of the animal's real economic value. Animals that on the whole are decidedly beneficial are habitually destroyed because they occasionally transgress. Thus, warfare is made on the skunk and many kinds of hawks and owls that occasionally destroy a chicken or a game bird but which habitually subsist upon harmful insects and rodents. Among the natural enemies of the rat are the larger hawks and owls, skunks, foxes, coyotes, weasels, minks, and a few other mammals. To these must be added the domestic dogs, cats, and ferrets.

HAWKS.

Several kinds of hawks feed on rats, usually during the season when the latter infest the fields; for hawks, because of persecution, do not often stay about farm buildings. Hence, ordinarily hawks have few opportunities to prey on these denizens of house and barn.

In open fields, however, rats often come out in daytime, especially in early morning and late afternoon. Hawks are then on the lookout for prey, and many a rat is killed by them. The species of hawks that most commonly feed upon rats are: The buzzard hawks (*Buteo*), including the red-tailed (*Buteo borealis* and subspecies), the red-shouldered (*B. lineatus*), the broad-winged (*B. platypterus*), and the Swainson (*B. swainsoni*); the rough-legged hawks (*Archibuteo*), two species; and probably the marsh harrier (*Circus hudsonius*).

OWLS.

In destroying rats owls are more efficient than hawks, because they hunt at night, when the rodents are most active. All American owls except the most diminutive species kill rats. Even the little screech owl (*Megascops asio*) often feeds upon the young.

Of all our owls, the barn owl (*Strix pratincola*) stands at the head in destructiveness to rats, since it often makes its home about farm buildings. Dr. A. K. Fisher, of the Biological Survey, has examined the pellets, or castings, of a pair of barn owls that live in the tower of the Smithsonian Institution in Washington and found in them skulls of 172 rats (*Mus norvegicus*). In addition, these birds had destroyed 1,285 field mice and 452 house mice.

Dr. John I. Northrop found a nest of the barn owl on Andros Island, Bahamas, which held two young birds not yet able to fly. The ground around the nest was covered with pellets which contained

remains of the black rat and no other species.[a] This circumstance shows that the birds feed on whatever rodents are most abundant and most easily obtainable. In the event of a general invasion of rats in any locality where these owls stay, the birds would be most efficient aids in their destruction.

The great horned owl (*Bubo virginianus*) is the largest of our resident owls, and usually is a most useful bird. True, he captures the farmer's fowls when roosting unsheltered on fences or in trees, but such loss is easily prevented. The owl captures many rats, especially when they are plentiful. Mr. Charles Dury, of Ohio, in 1886 published a letter from O. E. Niles in which the latter states that under one nest of the great horned owl he counted 113 dead rats.[b]

The snowy owl is a rather rare winter visitor in the United States. Usually it arrives when the ground is covered with snow and ordinary food is scarce. Near barns, outbuildings, and stacks the brown rat is its chief reliance, and if undisturbed these owls will stay for several weeks in the same locality feeding on these pests.

The practice of killing hawks and owls should be discouraged. Game preservers, especially, should realize that the birds of prey would, if permitted to live, destroy rats that in the course of a year do ten times as much damage to game as the birds. The custom of paying bounties for killing birds of prey is a most unwise expenditure of public funds, harmful in its immediate results and pernicious in its influence on the community.

WILD MAMMALS.

The wild mammals that destroy rats are not numerous, and few of them resort much to localities favored by rats. Chief among those that do good work for the farmer in rat destruction are skunks, minks, and weasels. These all resort to the haunts of the rat, and are, in the main, useful. The mink is the only one that does damage enough to nearly offset its usefulness in destroying farm pests.

Skunks.—Skunks are excellent ratters, and when they take up their abode on the premises of the farmer, will speedily destroy or drive away all rats and mice. This statement applies to both the large skunks (*Mephitis*) and the little spotted skunks (*Spilogale*). Unfortunately they are seldom allowed to tenant the premises without being molested by either dogs or men. When thus disturbed, the skunks emit the characteristic secretion, which is almost their only defense against enemies. Undisturbed, they are quite inoffensive and will stay about the farm buildings until rats and mice are no longer to be had.

Skunks usually hunt by night, and hence poultry properly housed is safe from them. The larger skunks can not climb, and do not

[a] The Auk, vol. 8, p. 75, 1891.

[b] Jour. Cincinnati Soc. Nat. Hist., vol 8, p. 63, 1886.

capture fowls that roost on elevated perches. Indeed, so few skunks ever kill poultry that warfare on the skunk family is not justified. Besides destroying mice and rats, skunks are invaluable to the farmer as consumers of noxious insects, particularly cutworms, army worms, tobacco worms, white grubs, May beetles, grasshoppers, crickets, and sphinx moths.

Weasels.—Weasels are good ratters and mousers. Several of the American species come about buildings and often perform excellent service in destroying rodents. They are more destructive to poultry than the skunk, for they can enter poultry houses through smaller openings, can climb to the roosts, and usually take more than one victim at a time.

These traits make them efficient in destroying rodents also. The smaller species of weasels can follow a rat into its burrow and to nearly all its usual retreats. A single victim rarely satisfies it, and in a very short time it clears stackyard or shed of rats and mice.

Our largest species of weasel, the black-footed ferret (*Putorius nigripes*), occasionally deserts its wild haunts and comes about buildings in search of rats and mice. At Hays, Kans., during the summer of 1905, a black-footed ferret took up its abode under the board sidewalk in the business part of the town, and the squealing of its victims was frequently heard.

As concerns the destruction of poultry by weasels, the same care necessary to exclude rats from the poultry house and yard will keep out the weasel also. When so excluded, the weasel does no harm about the premises, but may be depended upon to drive out or destroy the rats.

Minks.—Minks surpass weasels in their destructiveness to poultry, and they feed on fish also. While excellent ratters, the increasing value of mink furs causes the animals to be so closely hunted that in most parts of the country they now exert little influence upon the numbers of rodent pests or upon the fortunes of the poultry grower or the fish culturist.

The mongoose.—Among the natural enemies of rats are the various species of mongoose (*Herpestes* and *Mongos*). The mongoose was introduced into Jamaica and Hawaii many years ago to stay the depredations of rats upon sugar cane and other products. While it kills many rats, it does not exterminate them, and it has proved a great scourge to poultry and native birds. It destroys also many lizards and other insectivorous animals. For these reasons its importation into the United States is prohibited by law.

RAT-PROOF CONSTRUCTION.

The best way to exclude rats from buildings, whether in city or country, is by the use of cement in construction. As the advantages of this material are coming to be generally understood, its use is

rapidly extending to all kinds of buildings. Dwellings, dairies, barns, stables, chicken houses, ice houses, bridges, dams, silos, tanks, cisterns, root cellars, hotbeds, sidewalks, and curbs are now often made wholly of cement. The processes of mixing and laying this material require little skill or special knowledge, and workmen of ordinary intelligence can successfully follow the plain directions contained in handbooks of cement construction. Illustrated handbooks are often furnished free by cement manufacturers.

Many modern public buildings are so constructed that rats can find no lodgment in the walls or foundations, and yet in a few years, through negligence, such buildings often become infested with the pests. Sometimes drain pipes are left uncovered for hours at a time. Often outer doors, especially those opening on alleys, are left ajar. A common mistake is failure to screen basement windows which must be opened for ventilation. In whatever way the intruders are admitted, when once inside they proceed to intrench themselves behind furniture or stores, and it is difficult to dislodge them. The addition of inner doors to vestibules is an important precaution against rats. The lower part of outer doors to public buildings, especially markets, should be reinforced with light metal plates to prevent the animals from gnawing through.

In constructing dwelling houses the additional cost of making the foundations rat-proof is slight as compared with the advantages. The cellar walls should have concrete footings, and the walls themselves be laid in cement mortar. The cellar floor should be of "medium" rather than "lean" concrete, and all water and drain pipes should be surrounded with concrete. Even old cellars may be made rat-proof at comparatively small expense. Rat holes may be permanently closed with a mixture of cement, sand, and broken glass, or sharp bits of crockery or stone.

On a foundation like the one described above, the walls of a wooden dwelling also may be made rat-proof. The space between the sheathing and lath, to the height of about a foot, should be filled with concrete. Rats can not then gain access to the walls, and can enter the dwelling only through doors or windows. Screening all basement and cellar windows with wire netting is a most necessary precaution to exclude rats.

Rats sometimes gain access to houses by way of vines growing on the outer walls and reaching to open windows, and the means by which the animals come and go is a mystery to the household. Old growths of Virginia creeper or ivy often furnish such ladders for rats.

Rats often enter houses from sewers by way of soil pipes leading into water-closets. A number of instances of this kind were reported to the writer as having occurred in the city of Washington during the past year. The careful construction of drains and the use of

traps that rats can not pass through will prevent such invasion of dwellings.

In cities, aside from dwellings, the sewers, wharfs, stables, and outbuildings are the chief refuges for rats. Modern sewers are used by the animals only as highways and not as permanent abodes; but old-fashioned brick sewers often furnish nesting crannies. Openings from sewers to streets may easily be screened against rats, but with modern sewers this is unnecessary.

Wharfs, stables, and outbuildings in cities should be constructed with a view to exclude rats. Cement is the chief means to this end. Old, tumble-down buildings and wharfs should not be tolerated in any city, but should be condemned and destroyed.

Almost everywhere, in country, village, and city, the wooden floors of sidewalks, areas, and porches are commonly laid upon timbers resting upon the ground. Under these floors rats are safe from most of their enemies. Only municipal action can completely remedy these conditions, but all such rat harbors should be destroyed and replaced by cement floors. Considering durability, healthfulness, and other advantages, this material is the cheapest that can be used. The floors of wooden porches should always be well above the ground. Rats often undermine brick walks or areas.

Granaries, corncribs, and poultry houses may be made rat-proof by a liberal use of concrete in the foundations and floors; or the floors may be of wood resting upon concrete. Objection has been urged against the use of concrete floors for horses, cattle, and poultry, because the material is too good a conductor of heat and the health of the animals suffers from contact with floors of this kind. In poultry houses, dry soil or sand may be used as a covering for the cement floor; and in stables, a wooden floor resting on the concrete is just as satisfactory so far as the exclusion of rats is concerned.

The common practice of setting corncribs on posts with inverted pans at the top often fails to exclude rats, because the posts are not high enough to place the lower cracks of the structure beyond reach of the animals. The posts should project at least 3 feet above the surface of the ground, for rats are excellent jumpers. But a crib built in this manner, though cheap, is unsightly.

For a rat-proof crib a well-drained site should be chosen. The outer walls, laid in cement, should be sunk about 20 inches into the ground. The space within the walls should be thoroughly grouted with cement and broken stone and finished with "rich" concrete for a floor. Upon this the structure may be built. Even the walls of the crib may be concrete. Corn will not mold in contact with them, provided there is good ventilation and the roof is water-tight.

However, there are cheaper ways of excluding rats from either new or old corncribs. Rats, mice, and sparrows may be effectually

kept out by the use of either an inner or an outer covering of galvanized-wire netting of half-inch mesh and heavy enough to resist the teeth of rats. The netting in common use for screening cellar windows is suitable for covering cribs. As rats can climb the netting, the entire structure must be screened.

KEEPING FOOD FROM RATS.

The effect of an abundance of food on the breeding of rodents has already been mentioned. Well-fed rats mature quickly, breed often, and have large litters of young. Besides limiting reproduction, scarcity of food will make the measures to destroy the animals by traps, poisons, or bacterial cultures far more effective.

The general rat-proofing of buildings is the most important step in limiting the food supply of rats. But since much of the animals' food consists of garbage and other waste materials, it is not enough to bar rats from markets, granaries, warehouses, and private food stores. Garbage or offal of any kind must be so disposed of that rats can not obtain it.

In cities and towns an efficient system of garbage collection and disposal should be established by ordinances. Waste from markets, hotels, cafés, and households should be collected in covered metallic receptacles and emptied each day. Garbage should never be dumped in or near towns, but should be utilized or promptly destroyed by fire.

Rats find abundant food in country slaughterhouses; reform in the management of these is badly needed. It is a common practice to leave offal of slaughtered animals to be eaten by both rats and swine. Such places are not only centers of rat propagation, but are the chief means of perpetuating trichinæ in pork. All this should be changed by law. The offal should be promptly cremated or otherwise disposed of. There is no reason why country slaughterhouses should not be as cleanly as constantly inspected abattoirs.

Another important source of rat food is the remnants of lunches left by employees in factories, stores, and public buildings. This food, which alone is sufficient to attract and sustain a small army of rats, is commonly left in waste baskets or other open receptacles. Strictly enforced rules requiring all remnants of food to be deposited in covered vessels would make trapping far more effective.

If buildings are infested with rats, wire-screened compartments should be used for storing food. Many merchants now keep flour, seeds, meats, and the like in wire cages, and the practice should be general. Ice boxes and cold-storage rooms may be made proof against rats by an outer covering of heavy wire netting of half-inch mesh. Steamboat companies engaged in carrying high-priced southern produce to northern markets can, at small expense, protect the vegetables or fruits in screened compartments on both docks and vessels.

DRIVING AWAY RATS.

Many devices have been recommended for driving rats from premises. Some are based upon superstitions and have no merit; others are more or less practical. It should be remembered, however, that the community gains nothing when rats merely migrate from one dwelling or plantation to another. Nothing short of destruction of the animals is an adequate measure of relief. Occasionally, however, under certain circumstances it may be desirable to drive rats from a particular place, dwelling, or apartment.

Rats frequently shift their quarters, thus making it difficult to judge accurately the success of measures employed against them. They often of their own volition move to new grounds, and the change is wrongly attributed to means used to drive them away or to destroy them. This explains the diverse results that sometimes follow applications of the same remedy.

Among methods for driving away rats that have proved useful under some circumstances are the following:

1. Freshly slaked lime placed dry in all burrows and runs of rats.
2. Freshly made thin whitewash poured into the rat burrows.
3. A strong solution of copperas (ferrous sulphate) sprinkled in runs and burrow entrances.
4. Chlorid of lime, loose or wrapped in old rags, placed in burrows and runs.
5. Gas tar daubed about the burrow entrances.
6. Powdered red pepper scattered in rat runs and burrows.
7. Caustic potash placed in the burrows and runs.

The following have been so often suggested that they are mentioned here, though they have little to recommend them: Fastening a small bell to the neck of a live rat (by means of wire) and releasing the animal in the infested place; singeing or daubing with gas tar; feeding the rats plaster of Paris mixed with twice its bulk of meal, both dry. Of most of these the writer can not speak from experience. With reference to the last, however, it may be stated that caged rats ate plaster of Paris, mixed with flour or meal in various proportions, freely and without injury. The setting quality of the plaster was first carefully tested. Several days after the experiment the rats were killed and examined. Their digestive organs were in normal condition. These experiments completely disprove the often-repeated statement that plaster of Paris mixed with meal solidifies in the stomachs of rats. It may be stated further that the same rats ate freely and without harm pieces of cork and sponge that had been fried in lard. The results show that these substances, so frequently recommended, have no value in killing rats.

DESTROYING RATS.

The Biological Survey has made both laboratory and field experiments with various agencies for destroying rats. The results obtained form the chief basis for the recommendations set forth in the following pages.

TRAPS.

Owing to their cunning it is not easy to clear premises of rats by trapping. A few adults refuse to enter the most innocent-looking trap. And yet trapping, if persistently followed, is one of the most effective ways of destroying the animals. For general use the improved modern traps with a wire fall released by a baited trigger and driven by a coiled spring have marked advantages over the old forms, and many of them may be used at the same time. These traps, sometimes called guillotine traps, are of many designs, but the more simply constructed are to be preferred. Probably those made entirely of metal are the best, as they are more durable and are less likely to absorb and retain odors.

In illustration of the effectiveness of traps it may be related that about three years ago a large department store in Washington experienced heavy losses of gloves, lace curtains, and other merchandise from rat depredations. After they had made many unsuccessful attempts to abate the nuisance, the managers were advised to try the improved traps. As a result 136 rats were killed during the first 20 nights, when the losses practically ceased, and trapping has been continued in the store ever since with satisfactory results.

Guillotine traps should be baited with small pieces of Vienna sausage (Wienerwurst) or fried bacon. A small section of an ear of corn is an excellent bait if other grain is not present. The trigger wire should be bent inward to bring the bait into proper position to permit the fall to strike the rat in the neck, as shown in the illustration (fig. 2).

Other excellent baits for rats are oatmeal, toasted cheese, toasted bread (buttered), fish, fish offal, fresh liver, raw meat, pine nuts, apples, carrots, corn, and sunflower, squash, or pumpkin seeds. Broken fresh eggs are good bait at all seasons, and ripe tomatoes, green cucumbers, and other fresh vegetables are very tempting to the animals in winter. When seed, grain, or meal is used with a guillotine trap, it is placed on the trigger plate, or the trigger wire may be bent outward and the bait sprinkled under it.

When rats are numerous, the large French wire cage traps can be used to advantage. They should be made of stiff, heavy wire, well reenforced. Many of those sold in hardware stores are useless, because a full-grown rat can bend the light wires apart and escape.

Cage traps should be baited and left open for several nights until the rats are accustomed to enter them to obtain food. They should then be closed and freshly baited, when a large catch may be expected, especially of young rats. As many as 25, and even more, partly grown rats have been taken at a time in one of these traps.

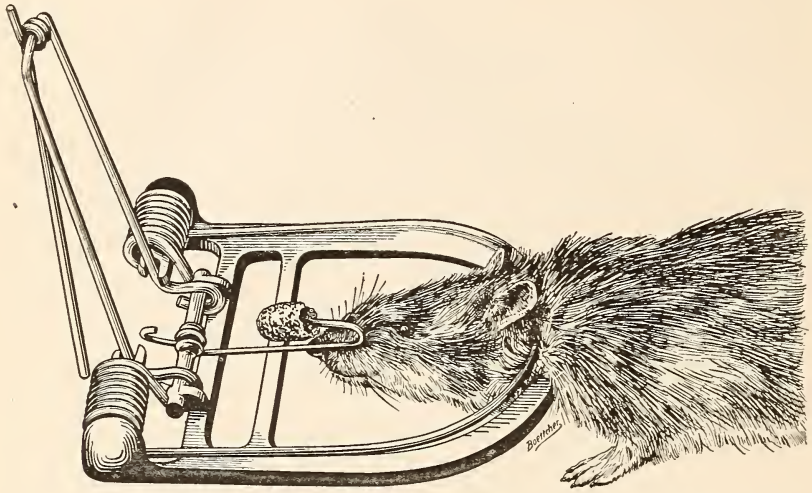

FIG. 2.—Method of baiting guillotine trap.

The editor of The Field (London), commenting on a letter from a correspondent who complained of lack of success with the cage trap, says:

> Rats are not fools and men are not always wise enough to circumvent them. We have had this trap lying in the open and not a rat would touch it, but taken up and a little refuse fish put into it and an old mat over it, we got some lovely specimens next morning. A successful trapper says that even when he gets a rat in this trap he does not disturb it, but feeds it, and sometimes he has 8 or 9 other rats come in to keep it company.[a]

The writer has had excellent success by concealing a cage trap under a bunch of hay or straw, and has found by experience that a decoy rat is useful. A commission merchant in Baltimore places the baited cage trap inside of a wooden box having a hole in one end and against which the opening of the trap is fitted. The box is then covered with trash and large catches are made.

Notwithstanding the fact that sometimes a large number of rats may be taken at a time in cage traps, in the long run a few good guillotine traps intelligently used will prove more effective.

The old-fashioned box trap set with a figure-4 trigger is sometimes useful to secure a wise old rat that refuses to be enticed into a modern

[a] The Field (London), vol. 89, p. 692, May 1, 1897.

trap. Better still is a simple deadfall—a flat stone or a heavy plank—supported by a figure-4 trigger. An old rat will go under such a contrivance to feed without fear.

The ordinary steel trap (No. 0 or 1) may sometimes be satisfactorily employed to capture a rat. The animal is usually caught by the foot, and its squealing has a tendency to frighten other rats. The trap may be set in a shallow pan or box and covered with bran or oats, care being taken to have the space under the trigger pan free of grain. This may be done by placing a very light bit of cotton under the trigger and setting as lightly as possible. In narrow runs or at the mouth of burrows a steel trap unbaited and covered with very light cloth or tissue paper is often effective.

The best bait to use in trapping is usually food of a kind that the rats do not get in the vicinity. In a meat market vegetables or grain should be used; in a feed store, meat. As far as possible, food other than the bait should be inaccessible while trapping is in progress. The bait should be kept fresh and attractive, and the kind changed when necessary. Baits and traps should be handled as little as possible. Ordinarily, traps should be frequently cleaned or smoked. The use of artificial scents, as oil of anise or rhodium, on the bait is advocated by many, but no doubt their importance has been exaggerated. The experience of the writer is not favorable to their use, but they may do some good by concealing the human odor on the trap.

Barrel trap.—About sixty years ago a writer in the Cornhill Magazine gave details of a trap by means of which it was claimed that 3,000 rats were caught in a warehouse in a single night. The plan involved tolling the rats to the place and feeding them for several nights on the tops of barrels covered with coarse brown paper. Afterwards a cross was cut in the paper, so that the rats fell into the barrel (fig. 3). Many variations of the plan, but few improvements upon it, have been suggested by agricultural writers since that time. Reports are frequently made of large catches of rats by means of a barrel fitted with a light cover of wood, hinged on a rod so as to turn with the weight of a rat (fig. 3).

Fence and battues.—In the rice fields of the Far East the natives build numerous piles of brush and rice straw and leave them for several days until many rats have taken shelter in them. A portable bamboo inclosure several feet in height is then set up around each pile in succession and the straw and brush are thrown out over the top while dogs and men kill the trapped rodents. Large numbers are killed in this way, and the plan with modifications may be utilized in America with satisfactory results. A wire netting of fine mesh may be used for the inclosure. The scheme is applicable at the removal of grain, straw, or haystacks, as well as brush piles.

In a large barn near Washington, a few years ago, piles of unhusked corn shocks were left in the loft and were soon infested with rats. A wooden pen was set down surrounding the piles in turn and the corn thrown out until dogs were able to get at the rats. In this way several men and dogs killed 500 rats in a single day.

Burmese rat trap.—The Burmese use an ingenious and simple method of trapping rats. A large jar with a weighted cover is sunken into the ground (fig. 4). A hole is punched in the side of the jar on a level with the surface of the ground and just large enough to

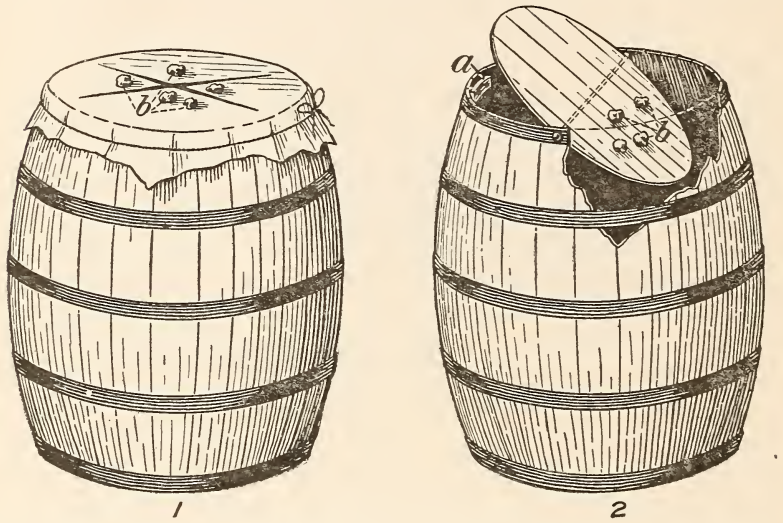

FIG. 3.—Barrel traps: 1, With stiff paper cover; 2, with hinged barrel cover; *a*, stop; *b*, baits.

admit a large rat. Paddy (rice) is used in the jar as a bait. A writer states that he saw 72 rats caught in one such trap the first night it was set.[a]

POISONS.

While the use of poison is the best and quickest way to get rid of rats, the odor from the dead animals makes the method impracticable in occupied houses. Poison, however, may be effectively used in barns, stables, sheds, cribs, and other outbuildings.

Among the principal poisons that have been recommended for killing rats are barium carbonate, strychnine, arsenic, and phosphorus.

Barium carbonate.—One of the cheapest and most effective poisons for rats and mice is barium carbonate.[b] This mineral has the advantage of being without taste or smell. It has a corrosive action on the mucous lining of the stomach and is dangerous to larger animals if

[a] The Field (London), vol. 35, p. 286, 1870.

[b] Barium carbonate, as well as some other salts of barium, is often called "barytes." In its native form it is known as "witherite." True barytes is barium sulphate, which is too insoluble for practical use as a poison for rats.

taken in sufficient quantity. In the small doses fed to rats and mice it would be harmless to domestic animals. Its action upon rats is slow, and if exit is possible, they usually leave the premises in search of water. For this reason the poison may frequently, though not always, be used in houses without disagreeable consequences.

Barium carbonate may be fed in the form of dough composed of four parts of meal or flour and one part of the mineral. A more convenient bait is ordinary oatmeal with about one-eighth of its bulk of the mineral, mixed with water into a stiff dough. A third plan is to spread the barium carbonate upon fish, toasted bread (moistened), or ordinary bread and butter. The prepared bait should

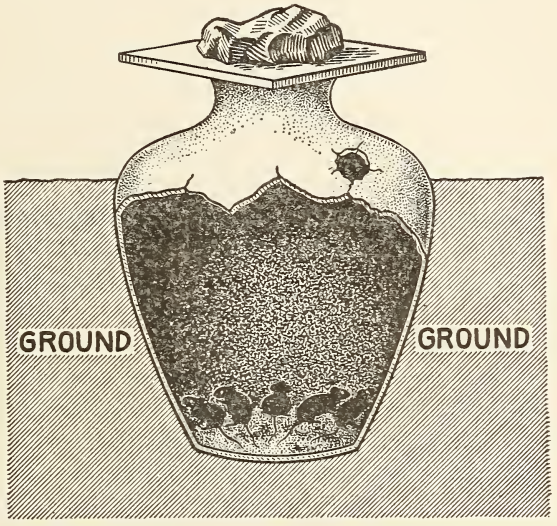

FIG. 4.—A Burmese trap.

be placed in rat runs, a small quantity—as a teaspoonful—at a place. If a single application of the poison fails to kill or drive away all rats from the premises, it should be repeated with a change of bait.

Strychnine.—Strychnine is too rapid in action to make its use as a poison for rats desirable in houses, but elsewhere it may be employed effectively. Strychnia sulphate is the form best adapted for use. The dry crystals may be inserted in small pieces of raw meat, Vienna sausage, or toasted cheese, and these placed in rat runs or burrows; or oatmeal may be moistened with a strychnine sirup, and small quantities laid in the same way.

Strychnine sirup is prepared as follows: Dissolve a half ounce of strychnia sulphate in a pint of boiling water; add a pint of thick sugar sirup and stir thoroughly. A smaller quantity of the poison may be prepared with a proportional quantity of water. In preparing the bait it is necessary that all the oatmeal should be moistened with

sirup. Wheat is the most convenient alternative bait. It should be soaked over night in the strychnine sirup.

The bitterness of strychnine often prevents rats from eating baits containing the crystals. This trouble may sometimes be overcome by first feeding the baits without the strychnine for several successive nights until suspicion is allayed.

Arsenic.—Nearly all commercial rat poisons have either arsenic or phosphorus as a basis; and while many of them are effective, the poison is often present in quantities too small to be fatal to rats. It has been proved by experiment that sometimes rats have great power of resistance to some poisons, particularly to arsenic. Yet arsenic is an excellent rat poison, as is shown by its continued popularity. Its cheapness commends it to favor; yet the experiments of the Biological Survey show that strychnine, measured by the results obtained, is really the cheaper poison for most rodents.

Powdered white arsenic (arsenious acid) may be fed to rats in nearly any of the baits mentioned under barium carbonate and strychnine. It has been used successfully when rubbed into fresh fish or spread on buttered toast. Another method is to mix twelve parts by weight of corn meal and one part of arsenic with whites of eggs into a stiff dough.

An old formula for poisoning rats and mice with arsenic is the following, adapted from an English source:

Take a pound of oatmeal, a pound of coarse brown sugar, and a spoonful of arsenic. Mix well together and put the composition into an earthen jar. Place a tablespoonful at a place in runs frequented by rats.

Phosphorus.—This is probably the most widely used poison for rats and mice, and undoubtedly it is effective when given in an attractive bait. The phosphorus paste of the drug stores is usually dissolved yellow phosphorus mixed with glucose or other substances. The proportion of phosphorus varies from one-fourth percent to 4 percent. The first amount is too small to be always effective, and the last is dangerously inflammable. When home-made preparations of phosphorus are used, there is much danger of burning the person or of setting fire to crops or buildings. In the western States many fires have resulted from putting out home-made phosphorus poisons for ground squirrels, and entire fields of ripe grain have been destroyed in this way. Even with the commercial pastes the action of sun and rain upon them changes the phosphorus and leaches out the glucose until a highly inflammable residue is left.

It is often claimed that when phosphorus is eaten by rats or mice it dries up or mummifies the bodies so that no odor results. The statement has no foundation in fact. Equally misleading is the

statement that rats poisoned with phosphorus do not die on the premises. Owing to its slower operation, no doubt a larger proportion escape into the open before dying than when strychnine is used.

The Biological Survey does not recommend the use of phosphorus as a poison for rodents.

Caution.—In the United States there are few laws which prohibit the laying of poisons on lands owned or controlled by the poisoner. Hence it is all the more necessary to exercise extreme caution to prevent accidents. In several States notice of intention to lay poison must be given to persons living in the neighborhood. Poison for rats should never be placed in open or unsheltered places. This applies particularly to the use of strychnine or arsenic on meat.

Poison in poultry houses.—For poisoning rats in buildings and yards occupied by poultry, the following method is recommended: Two wooden boxes should be used, one considerably larger than the other, and each having two or more holes in the sides large enough to admit rats. The poisoned bait should be placed on the bottom and near the middle of the smaller box, and the larger box should then be inverted over the other. Rats thus have free access to the bait, but fowls are excluded.

The following methods of poisoning rats are quoted as useful under certain circumstances:

"I took a box, made several holes in it, turned it upside down, mixed strychnine and cheese together and put it under the box. I then placed a heavy weight on the box so that no domestic animal could get at it and put it in the granary and corncrib. This poison is best because it acts so quickly that rats do not have time to get back to their holes or crawl where any domestic animal can get at them and they can be gathered up and buried." [a]

A writer in the Agricultural Gazette used barium carbonate on herrings, after first feeding the rats liberally on herrings to give them confidence. After a couple of nights' feeding, the poisoned herrings were substituted. The barytes was rubbed into the herrings with a stick. Many rats were killed. [b]

Use any kind of wooden box, like an old packing case. Make three or four holes in each box large enough to allow a rat to enter. Feed meal for several days; then omit for one day. Then mix arsenic with the meal. [c]

To destroy rats on farms.—Each evening when the cows are milked place a little fresh milk in a shallow pan where the rats can get it.

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[a] A. E. L. in Mo. Valley Farmer for April, 1907.

[b] American Agriculturist, vol. 9, p. 257, August, 1850.

[c] The Field (London), vol. 96, p. 624, October 30, 1900.

Continue this for a week or more until the rats get bold and impatient to get at the milk. Then mix arsenic with the milk and await results. This plan is said to entirely clean a barn of rats.[a]

DOMESTIC ANIMALS.

Among the domestic animals often employed to kill rats are the familiar dog, cat, and ferret.

Dogs.—The value of dogs as ratters can not be appreciated by persons who have had no experience with a trained animal. The ordinary cur and the larger breeds of dogs seldom develop the necessary qualities for ratters. Small Irish, Scotch, and fox terriers when properly trained are superior to other breeds, and under favorable circumstances may be relied upon to keep the farm premises reasonably free from rats.

With some preliminary training most terriers learn to hunt rats independently and thus become doubly useful on the farm. Several terriers owned in Washington are said to have destroyed over 1,000 rats each, and the owner of one of them states that his dog has killed that number in one year. A young terrier kept in the National Capitol is said to have destroyed over 400 rats in that building.

Cats.—However valuable cats may be as mousers, few of them learn to catch rats. The ordinary house cat is too well fed and consequently too lazy to undertake the capture of an animal as formidable as the brown rat. Birds and mice are much more to its liking.

Ferrets.—Tame ferrets, like weasels, are inveterate foes of rats, and can follow the rodents into their retreats. Under favorable circumstances they are useful aids to the rat catcher, but their value is greatly overestimated. For effective work they require experienced handling and the additional services of a dog or two. Dogs and ferrets must be thoroughly accustomed to each other, and the former must be quiet and steady instead of noisy and excitable. The ferret is used only to bolt the rats, which are killed by the dogs. If unmuzzled ferrets are sent into rat retreats, they are apt to make a kill and then lie up after sucking the blood of their victim. Sometimes they remain for hours in the burrows or escape by other exits and are lost. There is danger that these lost ferrets may adapt themselves to wild conditions and become a pest by preying upon poultry and birds.

FUMIGATION.

Rats may be destroyed in their burrows in the fields and along river banks, levees, and dikes by the use of carbon bisulphid. A wad of cotton or other absorbent material is saturated with the liquid and then pushed into the burrow, the opening being packed with earth to prevent the escape of the gas. All animals in the

[a] E. H. Reihl, in Colman's Rural World, vol. 61, p. 27, January 29, 1908.

burrow are asphyxiated. Fumigation in buildings is rarely effective, because it is difficult to confine the gases. Moreover, when effective, the odor from the dead rats is highly objectionable.

Chlorin, carbon monoxid, sulphur dioxid and hydrocyanic acid are the gases most used for destroying rats and mice in sheds, warehouses, and stores. Each is effective if the gas can be confined and made to reach the retreats of the animals. Owing to the great danger from fire incident to burning charcoal or sulphur in open pans, a special furnace provided with means for forcing the gas into the compartments of vessels or buildings is generally employed.

Hydrocyanic-acid gas is effective in destroying all animal life in buildings. It has been successfully used to free elevators and warehouses of rats, mice, and insects. However, it is so dangerous to human life that the novice should not attempt fumigation with it, except under careful instructions. Directions for preparing and using the gas may be found in "Hydrocyanic-acid Gas against Household Insects," by Dr. L. O. Howard.[a]

Carbon monoxid is rather dangerous, as its presence in the hold of a vessel or other apartment is not manifest to the senses, and fatal accidents have occurred during its employment to fumigate vessels.

Chlorin gas has a strong bleaching action upon textile fabrics and for this reason can not be used in many situations.

Sulphur dioxid also has a bleaching effect upon textiles, but less marked than that of chlorin and ordinarily not noticeable with the small percentage of the gas it is necessary to use. On the whole, this gas has many advantages as a fumigator and disinfectant. It is successfully employed also as a fire extinguisher on board vessels.

The port regulations for destroying rats to prevent the introduction of plague and to disinfect merchandise and personal effects of passengers have generally been made to conform to the opinion of health officers that thorough fumigation with sulphur dioxid forced into every part of a ship meets all requirements, and the long delays of quarantine are thus avoided. A number of important steamship companies have fitted their vessels with special apparatus for generating the gas and forcing it into the compartments of their ships, and the authorities of some ports have fitted the docks with such apparatus for use on all incoming vessels.

While the chief object of the port regulations for disinfecting ships is to prevent the introduction of plague and similar diseases, the advantages of having vessels free from rats and other vermin are of sufficient importance to warrant the outlay for apparatus. The numbers of rats on shipboard and the amount of mischief they are capable of are not always appreciated. A French maritime journal

[a] Circular 46, Bureau of Entomology, U. S. Dept. of Agric., 1907.

is authority for the statement that in May, 1901, after the steamship *Minnehaha* of the Atlantic Transport Company had been disinfected at the London dock by the use of sulphur dioxid over 1,300 dead rats were found in the holds. The vessel had been in commission only about nine months, carrying flour, grain, and provisions between New York and London, and the finding of so many rats was a complete surprise to the ship's officers.

MICRO-ORGANISMS.

At irregular intervals when rodents become overabundant, contagious diseases break out and destroy large numbers. Such diseases have been known to occur among ground squirrels, prairie dogs, rabbits, lemmings, house mice, field mice, and rats. They occur also, occasionally, where numbers of the animals are brought together in confined quarters. Observations of such epidemics have encouraged bacteriologists to experiment in inducing diseases artificially for the purpose of destroying rodent pests.

The problem of the bacteriologist is to find an organism that will destroy a given species by contagious disease, and yet be harmless to all other animals, whether wild or domesticated. From a scientific standpoint some progress has been made toward the solution of such problems, but practical results are still lacking. The rat has been the subject of more experiments than any other animal, but attempts to destroy it by epidemics have not yet advanced beyond the experimental stage.

Several micro-organisms, or bacteria, have been exploited in Europe and America for destroying rats. A number are on the market in the United States. The Biological Survey has made laboratory and field experiments with some of them, and has also received many reports from others who have tried the cultures in a practical way. The results are by no means uniform, although the majority are negative. The cultures tested by the Survey have given poor results.

The chief defects to be overcome before the cultures can be recommended for general use are—

1. The virulence is not great enough to kill a sufficiently high percentage of rats that eat food containing the micro-organisms.

2. The virulence decreases with the age of the cultures. They deteriorate in warm weather and in bright sunlight.

3. The diseases resulting from the micro-organisms are not contagious and do not spread by contact of diseased with healthy animals.

4. The comparative cost of the cultures is too great for general use. Since they have no advantages over the common poisons, except that they are harmless to man and other animals, they should be equally cheap; their actual cost is much greater. Moreover, con-

sidering the skill and care necessary in their preparation, it is doubtful if the cost can be greatly reduced.

However, the possibilities in the use of contagious diseases for destroying rats have not been exhausted. It is not improbable that a virulent bacterium, pathogenic for rats and similar rodents only, exists, and that vigilant search will discover it. Bacteriological science is in its infancy and may be expected to make further discoveries of great economic importance. A rat disease, truly contagious, harmless to other animals, and capable of being used at will would be a boon worth many millions of dollars annually to the people of the United States.

ORGANIZED EFFORTS TO DESTROY RATS.

The necessity of cooperation and organization in the work of rat destruction should not be overlooked. To destroy all the animals on the premises of a single farmer in a community has little permanent value, since they are soon replaced from near-by farms. If, however, the farmers of an entire township or county unite in efforts to get rid of rats, much more lasting results may be attained. Such organized efforts repeated with reasonable frequency are very effective.

Cooperative efforts to destroy rats have taken various forms in different localities. In cities municipal employees have occasionally been set at work hunting rats from their retreats with at least temporary benefit to the community. Thus, in 1904, at Folkestone, England, a town of about 25,000 inhabitants, the corporation employees, helped by dogs, in three days killed 1,645 rats.[a]

Side hunts in which rats are the only animals that count in the contest have sometimes been organized and successfully carried out. At New Burlington, Ohio, a rat hunt took place November 26, 1866, in which each of the two sides killed over 8,000 rats, the beaten party serving a Thanksgiving banquet to the winners.[b]

At about the same period county agricultural societies sometimes offered prizes to the family presenting the largest number of rat tails as evidence that the animals had been destroyed. Even as late as May 2, 1907, in one of the counties of Kentucky, by general consent, the day was set apart for killing rats, and, according to newspaper reports, was quite generally observed.

There is danger that organized rat hunts will be followed by long intervals of indifference and inaction. This may be prevented by offering prizes covering a definite period of effort. Such prizes accomplish more than municipal bounties, because they secure a

[a] The Field (London), vol. 104, p. 98, July 16, 1904.
[b] American Naturalist, vol. 26, p. 8, January, 1867.

friendly rivalry which stimulates the contestants to do their utmost to win.

In England and some of its colonies contests for prizes have been organized to promote the destruction of the European house sparrow, but many of the so-called "sparrow clubs" are really sparrow and rat clubs, for the destruction of both pests are avowed objects of the organization. A sparrow club in Kent, England, secured the destruction of 28,000 sparrows and 16,000 rats in three seasons, by the annual expenditure of but £6 ($29.20) in prize money.[a] Had ordinary bounties been paid for this destruction, the tax on the community would have been about £250 (over $1,200).

AN INTERNATIONAL SOCIETY.

Perhaps the most extensive campaign ever organized against rats is that undertaken by L'Association Internationale pour le Destruction Rationelle des Rats, a society which originated in Denmark and was organized through the influence of a civil engineer named Emil Zuschlag. The purposes of the society are to spread information concerning the mischief done by rats and to carry on a general campaign for their destruction. The influence of the organization has already borne fruit in increased activity in fighting rats in Denmark, Sweden, Saxony, and other countries. In Denmark and Sweden a system of small bounties for killing rats has for several years been in general operation in some of the larger cities, and the Danish Parliament has made appropriations to assist municipalities throughout that Kingdom in paying premiums for the work of destruction. General supervision of the work is in the hands of the society, which receives regular quarterly reports of progress made in the various municipalities. The form of report is shown in Plate III, which is an exact copy of the report for the city of Copenhagen for the last quarter of 1907. The premiums paid are usually small—from 5 to 10 öre ($1\frac{1}{3}$ to $2\frac{2}{3}$ cents) for each rat. Mr. Zuschlag recently reported that under the Danish law appropriating government funds for the prosecution of the society's work, 1,141,293 rats were destroyed during the first year, ending July 1, 1908.[b]

In the city of Copenhagen and its suburbs the campaign began in December, 1899, and 103,000 rats were destroyed during the first eighteen weeks. The premium paid was 10 öre for each rat, but other expenses brought the total cost to about $3,450. The society estimated that during one year 100,000 rats would commit depredations upon property amounting to $97,820; by the work of destruction the city had, therefore, been saved the sum of $94,370.[c] During

[a] Jour. Board of Agr. Great Britain, vol. 9, p. 342, 1902.

[b] Jour. Inc. Soc. for Dest. Vermin, vol. 1, p. 32, October, 1908.

[c] Le Rat Migratoire, Emil Zuschlag, p. 62, Copenhagen, 1908.

Kobenhavns Kommunes Indbyggerantal 367881

Kommunes Postadresse Kobenhavn

INDBERETNING

i Henhold til Lov af 22. Marts 1907 og Indenrigsministeriets Cirkulære af 1. Maj 1907 til Oplysning om de i Kobenhavns Kommune i Oktober Kvartals Maaneder dræbte Rotter og de for disse udbetalte Beløb.

Præmiens Størrelse pr. Rotte 8 Øre.

Oktober Maaned 1907	Antal dræbte Rotter	Udbetalt Præmiebeløb Kr.	Øre	Andre Udgifter Kr.	Øre	Udbetalt ialt Kr.	Øre
1ste Uge	2001	160	08				
2den -	2526	202	08				
3die -	2643	211	44	Landbohøjskolen			
4de -	3529	282	32				
5te -	1952	156	16	432	00		
Tilsammen	12651	1012	08	432	00	1444	08
November Maaned 1907							
1ste Uge	3797	303	76	Landbohøjskolen			
2den -	4099	327	92				
3die -	4170	333	60				
4de -	4362	348	96	416	00		
5te -	1302	104	16				
Tilsammen	17730	1418	40	416	00	1834	40
December Maaned 1907							
1ste Uge	4594	367	52	Rekvisiter			
2den -	5374	429	92	7	35		
3die -	5270	421	60	Landbohøjskolen			
4de -	3446	275	68	428	00		
5te -	1451	116	08	Landbohøjskolen Rottefælden			
				1641	69		
Tilsammen	20135	1610	80	1477	04	3087	84

Ialt for Kvartalet:

Antal af dræbte Rotter: 50516

Udbetalt for Præmier: 4041 Kroner 28 Øre.

Indsendt til Foreningen til lovordnet Udrydelse af Rotter, Colbjørnsensgade 14, Kjøbenhavn B.

Kobenhavn den 3 Januar 1908

For Kobenhavns Kommune.

(Underskrift).

COPY OF QUARTERLY REPORT OF THE RATS DESTROYED IN COPENHAGEN, OCTOBER, NOVEMBER, AND DECEMBER, 1907.

the last two quarters of 1907, in the same city, 83,832 rats were killed. The premiums, 8 öre per rat, amounted to $1,787.36 and the other expenses to $1,198.60, a total of $2,985.96.

In the city of Stockholm, Sweden, the organized work of destroying rats began in February, 1901, and has progressed steadily for the past seven years. The premium paid is 5 öre per rat and the total number of animals upon which the bounty was paid during the first six years follows: 1901 (11 months), 146,191 rats; 1902, 96,443 rats; 1903, 95,348 rats; 1904, 106,263 rats; 1905, 103,233 rats; 1906, 92,037 rats; 1907, 72,282 rats; a total for seven years of 711,797 rats, upon which the premiums amounted to about $9,540. The results here given are hardly encouraging to those who hope for speedy extermination of these pests in large cities. It shows that the animals reproduce almost as rapidly as they are destroyed under the stimulus of a very small premium.

The Danish Society for Rat Extermination has a membership of over 2,000 of the leading citizens of the Kingdom. It has interested and enrolled in its work leading men throughout Europe, and will undoubtedly exert a potent influence for good upon the entire world. As a public policy in America the wisdom of offering bounties for the destruction of noxious animals is open to question, but the Danish society does not confine its work to advocating a single plan for rat destruction. Its chief importance lies in its ability to awaken general interest in the work and to secure cooperation and system in carrying out definite plans.

The influence of the Danish society has been manifested recently in the organization in England of the Incorporated Society for the Destruction of Vermin. The objects of attack are not only rats and mice, but also sparrows, ticks, fleas, mosquitoes, and flies. The immediate activities of the society are to be directed against the brown rat, of which species the society estimates that 40,000,000 exist in the British Islands. The first number of a quarterly periodical devoted to the objects of the society appeared in October, 1908, and considerable interest has already been aroused.

SUMMARY OF RECOMMENDATIONS.

The following are important aids in limiting the numbers of rats and reducing the losses from their depredations:

1. Protection of our native hawks, owls, and smaller predatory mammals—the natural enemies of rats.

2. Greater cleanliness about stables, markets, grocery stores, warehouses, courts, alleys, and vacant lots in cities and villages, and like care on farms and suburban premises. This includes the storage of waste and garbage in tightly covered vessels and the prompt disposal of it each day.

3. Care in the construction of buildings and drains so as not to provide entrance and retreats for rats, and the permanent closing of all rat holes in old houses and cellars.

4. The early thrashing and marketing of grains on farms, so that stacks and mows shall not furnish harborage and food for rats.

5. Removal of outlying straw stacks and piles of trash or lumber that harbor rats in the fields.

6. Rat-proofing of warehouses, markets, cribs, stables, and granaries for storage of provisions, seed grain, and feedstuffs.

7. Keeping effective rat dogs, especially in city warehouses.

8. The systematic destruction of rats, whenever and wherever possible, by (*a*) trapping, (*b*) poisoning, and (*c*) organized hunts.

9. The organization of "rat clubs" and other societies for systematic warfare against rats.

O